How to Improve Team Collaboration in an Office environment with the help of Large Screen Displays

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Displays of various sizes and forms have found its way to the modern collaborative setting. The research community is interested in studying how such settings can be improved but there still exists a gap in defining what kind of displays are best for what purposes and what kind of cues would be suitable for a particular display. It is interesting to learn how well an application built for a small display can work on a larger one and how seamlessly such system can switch context between displays. For example, a PowerPoint Presentation, designed for desktop screens are normally manipulated with the help of a mouse. But when they are displayed on a larger screen, is there a possibility for it to adapt to the dynamics of the new system? And also, how can the screen designs be adapted based on the location of the display for e.g. in a public, semi-public and a private setting. The effect of proximity to the display also affects how users tend to interact with them. There is an increasing need to understand such possibilities from the user's perspective and to devise new technologies for the betterment of collaborative meetings.

This research reflects on a modern collaborative setting involving multiple displays and lists out the main pain points of using such systems and suggests design guidelines to overcome these. The outcome emerged from the study suggests that all collaborative settings should be built towards providing three main functions: Visibility, Flexibility and Involvement.

Key words and terms: collaboration, meeting, interaction, large screen display, gesture, mobile

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Contents

1. Introduction

In every organization, be it academic or industry based, being successful or making big strides, relies on the effective management of a number of small tasks. And in such cases, communication forms a crucial aspect in getting things done coherently. When individuals are faced with a common problem, the advantages of discussion, disagreement, justification and prompt action becomes the difference between a solution and an issue [Electrica et al., 1999]. Having a collaborative environment to exercise these options provides an opportunity for growth, both for the organization as well as the individual.

In this modern era of globalization, companies and their resources are spread around the world and has to cater to customers across various regions and as such, effective communication becomes a key element in running such enterprises. These professionals use various means of communication such as emails, meetings, online chat forums and face-to-face communication to get their work done. They rely heavily on various tools such as Skype Business, Team viewer, Confluence, Jira and so on, to collaborate and keep track of their tasks and deadlines.

The key technical issues that employees and managers have to deal with, while being in an overseas collaborative work set up are related to content sharing and allocation of responsibilities. Time zone differences, cultural differences, language barriers and varying work ethics are some of the other hindrances to efficient working. During the course of this study, we have isolated some of these issues and have tried to find possible solutions to them. According to Yasuoka [2015] one of the major risks with collaborative teams comprising overseas members is the breakdown of communication due to the differences in practices and cultural background. He says,

".. a key in such collaboration support resides in the collective creation process rather than the minimizing of differences or understanding of one another's social world. Professionals in design often maintain different social worlds and their understanding of others within them, even though they collaborate for a collective concern." [Yasuoka, 2015].

However, I do believe that a collective creation process can and would benefit largely by the understanding of each other's practices, both intercultural and interpersonal. According to Keith Sawyer [2007], having intercultural members and teams, improve creativity and innovation. The difficulties related to intercultural collaboration can be

neglected when you weigh the benefits of having individuals with different backgrounds and thought processes getting together to conduct work.

Keeping this in mind, the thesis aims to be an initial step in understanding the vast area of collaborative research in office environment by incorporating learnings from previous research, and by devising new solutions to existing problems. The study will seek to learn what kind of information would provide clarity to a software project's progress for different internal stakeholders and how a large in-office display could facilitate collaboration amongst them. In the later stage, this thesis explores various design ideas for the large display focused on the 'team meeting' scenarios and conducts user studies on a prototype created based on this design. We have attempted to use multiple modes of interaction incorporating gesture control and mobile interaction in this prototype. The results and the conclusion from this study is provided at the end of this thesis.

1.1 Research question

How to improve team collaboration in an office environment with the help of a large screen display? In the introduction chapter, we spoke about how a collaborative set up is becoming more and more relevant in today's social and economic construct. The idea of 'one world' is now more a reality than just an idea. The next step was to question strictly from a technological point of view, how can we facilitate this? The closest thing to meeting your client in person is to meet them virtually. Video and audio assistance has been around for a few years now, but more than that, how can we ensure the consistent presence (or the illusion) of an individual or a group of individuals who are not physically present in a meeting room. How can we make the idea of collaboration more holistic, moving away from the idea of "just a Skype meeting"? The first step to answering this question was to narrow down the question itself. By focusing on large screen displays within an office environment, we have ample space for exploration and at the same time can avoid the risk of generalising the term 'collaboration'. As a means to achieving this, studying human behaviour and observing real life scenarios was the first stride. The following image gives an overview of all the steps taken during the course of this study in order to try and seek answers to this research question.

1.2 Thesis breakdown

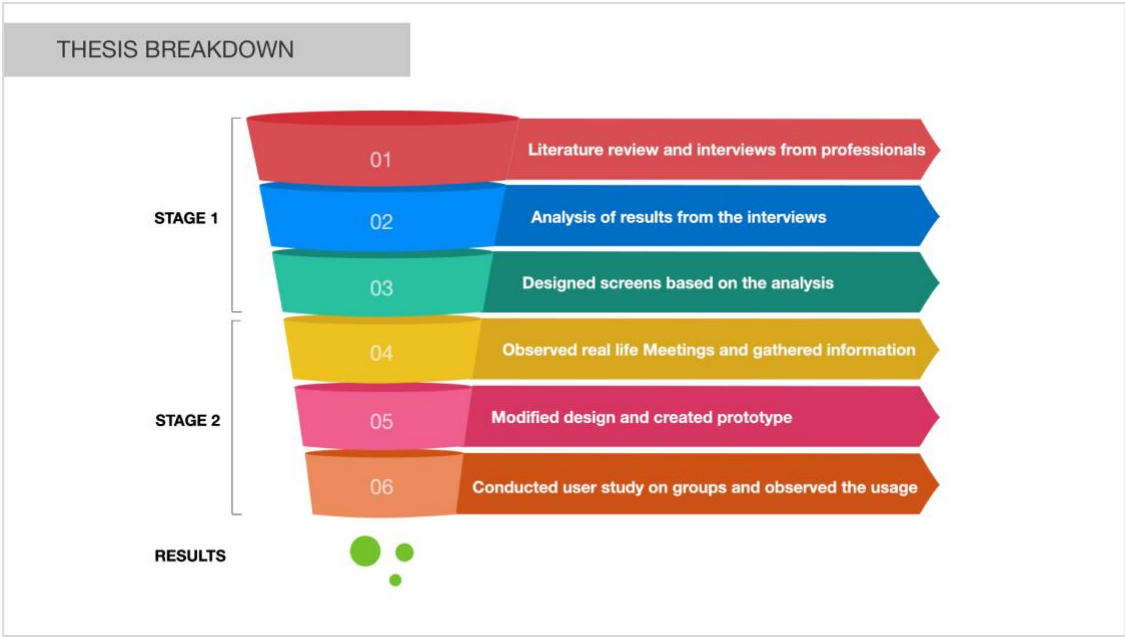

Figure 1. Thesis Breakdown

This thesis study can be divided into two stages:

Stage 1- Research, analysis and initial design

The first stage of the thesis consists of research and analysis where data was gathered on how a large screen display can improve team collaboration. During this stage, previous research and literature was referred to and the data collected helped create wireframes for various collaborative scenarios in an office environment. The next step was to validate these wireframes and this was done by conducting interviews with professionals in the field. The interview contained questions relating to their day-to-day work and also sought for comments and feedback on the wireframes. From the information gathered and analysed from this exercise, it was decided that the next set of screens would be designed pertaining to one particular scenario. Thus the "Meeting" scenario was chosen. A set of screens were then designed to cater to the requirements of the "Meeting scenario".

Stage 2- Modifying the design, creating a prototype and user study

The next step was to see how these screens can be further modified and applied to real life scenarios. For this purpose, information was gathered from observing real-life meetings. This is where Stage 2 begins. The previously designed screens were modified based on the results of this observation. The next step describes the implementation of this design, where an interactive web based prototype was developed. In the final step, this prototype was tested with 3 groups of participants. The results from interviewing

these participants and also from the observation made from their usage of the prototype, we arrived at a set of conclusions. This is the final product of this thesis study.

2. Large display in workplaces

Large screen displays have become more prevalent in the last couple of decades with the advancement in research and technology, not only in areas like military and telecommunication, but also in homes and office spaces. A major benefit of using large screen displays in workplaces is the real estate it provides and how that benefits group work. Apart from group behaviour, the individual benefits are also significant. A study conducted by Tan et al. [2006] compared user's performance while working on a desktop monitor *vs* a large projected wall display (Figure 2). From the experiments conducted, it was concluded that large displays are more immersive and prompted users to adopt egocentric strategies which helped them in spatial tasks such as 3D navigation.

Figure 2. User working on a small display and a large display. [Tan et al., 2006]

In the psychological perspective, large displays were seen to help retain attention and cause the highest levels of arousal as compared to other small and medium devices [Reeves et al., 1999] . In the study by Reeves et al. [1999], they talk about how users tend to specialize a certain object based on its prior usage. For e.g., viewers tend to prefer larger screens for watching certain forms of entertainment like movies or sports and can prefer smaller screens in their rooms when they need to calm down.

2.1 Designing for large displays

User experience (UX) in simple terms can be summarized as understanding the needs of a user and providing them with something more. It focuses not only on the basic usability of a system, but also on how to seamlessly integrate it with the other underlying systems and services in order to provide an effective and valuable product experience.

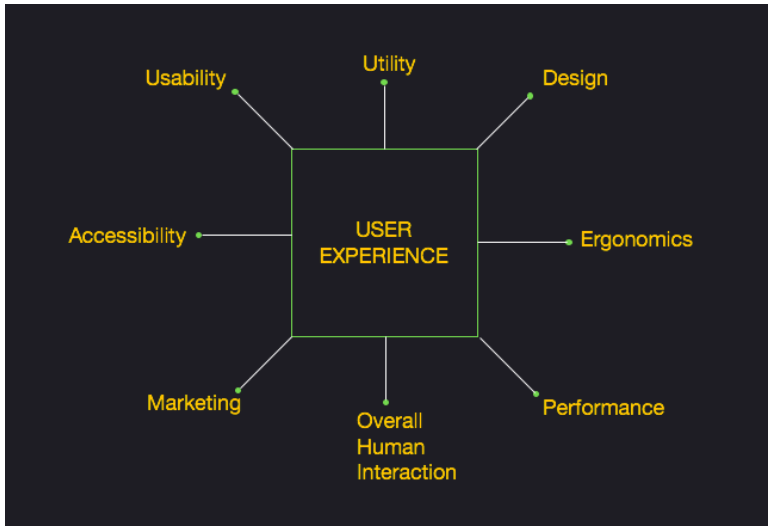

Figure 3. User experience and it's subsets

According to Nielsen [2006], while referring to the idea of User Experience, it is important to distinguish it from other related terms such as *user interface* and *usability*. This can be done with the help of the following example. Consider a smart phone application, which provides you with the timetable of the buses in your area. The UI may be perfect, but the UX will suffer if the user is not notified about a delay in the arrival of a bus due to a roadblock or any other traffic restriction. Furthermore, the application should provide alternative routes the user can take in order to get to his destination. A good design has to factor in such scenarios that add value to the application and ultimately provide satisfaction to the user. Usability with respect to ease of use and ease of learning can be considered as a subset of UX (Figure 3).

Designing any interface requires meticulous planning, constant feedback and also a set of fundamental rules to abide by. Gestalts principle of design [Koffka, 1935] devised in the early 1920s are a set of such laws that describe how we visually perceive certain things. Many of these principles are followed by designers around the world to make coherent, unified designs. Chang et al. [2002] in their study, identified eleven distinct Gestalt's laws and applied them to redesign an application called 'WoundCare' which is an educational multimedia tool for nursing students. Their findings were implemented and the result was a revised screen design for the medical application. The participants found the revised screens to be more efficient and easy to work with. These fundamental rules of proximity, similarity, simplicity and furthermore, can be applied to screens of all sizes.

Somervell et al. [2003] devised a set of usability heuristics predominantly for systems that come under the classification of *notification systems* [McCrickard and

Chewar, 2003]. These heuristics were tailor made to evaluate LSIEs or *large screen information exhibits* like Liveboard [Elrod et al., 1992] and other Smartboards. According to Somervell et al., these LSIEs focus on three goals: high-level comprehension, self-defined interruption and appropriate reaction. *High level comprehension* implies the user's ability to assess the information on the display and to retain it in memory. *Self-defined interruption* is allowing the user to decide when he wants to see an information and reduce the distraction caused by the information on the display. They studied specific problem areas related to existing large screen exhibits and formulated a guideline to improve future designs.

In a study conducted by Dudfield et al. [2011] on the cognitive benefits of large screen displays (LSD), they came up with the following 3 generic guidelines on designing interfaces for LSDs. They were: *i) Support for communication ii) Taking care of individual roles* and *iii) Designing for the team.* Their findings helped design future LSDs that optimises performance for military command teams.

2.2 Devices and Modalities used for interaction with large displays

Interacting with public displays has been challenging due to various factors like viewing distances, input capabilities, location and size of displays. Due to this, the major life span of most public displays get limited to advertisements and displaying posters [Boring and Baur, 2013]. Even with the introduction of various devices and modalities like gesture, speech etc., the full potential of these displays have not yet been reached.

Displaying contextually appropriate information to the user dictates the difference between his usage of the display as a kiosk *vs.* the display being a part of his everyday interaction [Russell and Gossweiler, 2001]. This can be achieved by designing systems that seamlessly incorporates devices and contextual information around the user's ecosystem.

In her journal article, [Oviatt, 1999] describes the myths surrounding multimodal interactions involving gesture and speech. According to her observations, in a system where speech and gesture are interdependent to perform an action, their occurrence is synchronised but not always simultaneous (Figure 4). What this means is that, only 25% of the commands performed by the user actually contain a spoken deictic that overlaps with the pointing needed by the system to predict its meaning. Thus multimodal systems should be designed taking into account such variations in user patterns.

Figure 4. A sequentially integrated multimodal command with pen input preceding speech and a brief lag between these signals. [Oviatt, 1999]

In a study conducted by Krahnstoever et al. [2002], they used both gesture and speech as the input modalities for interacting with large screen displays. These two modalities were tightly coupled in order to recognise and extract reliable information from the user. Even though the system was capable of recognising natural gestures, it was not enough to understand the complete intent of the user. According to them, the following aspects are important to achieve user satisfaction while using a multimodal system associated to a large display: *i) Smooth interaction initiation ii) Robust real-time visual processing iii) Error recovery* and *iv) Graceful interaction termination.* These are also some of the key aspects taken into account while designing the application for this thesis study.

2.3 Cross Device Interaction

Various researches have explored the possibilities and experimented with multiple modes of interaction with large displays over the years. The increase in popularity of mobile devices has opened up a new avenue for interacting with larger displays. One of the advantages of using such devices is their ready availability. Usage of Bluetooth pairing and QR code scanning are examples of information sharing methods between different kinds of devices that the users are familiar with already. The following section describes some of the research that has been done with cross-device interaction in detail.

According to Cavens et al. [2002], data exploration in large screen displays requires efficient input devices or modalities. In their study, they compared a modified laser pointer (modified by adding buttons to it so that it resembles the functionality of a computer mouse), with a standard mouse and an Interlink RemotePoint RF (a pressure sensitive input device often bundled with video projectors). They conducted the Fitts and Tunnel task [Accot and Zhai, 1997] on a projected display which concluded that while the modified laser pointer's performance was comparable to the regular mouse, it was significantly better than that of the RF pointer. In the next part of the study, they compared two laser pointers where one of the laser points was made invisible by using

infrared. In this scenario, for both the Fitts and Tunnel tasks, the visible laser pointer outperformed the infrared one. This concluded that a laser pointer with additional button can be used as an effective input device to interact with large displays.

Boring and Baur [2013] built two prototype applications to study interaction concepts for mobile devices and large screen displays. The first prototype was named *Virtual Projection* and it allowed users to project the content of their mobile phones onto a large display. This allowed users to edit content on the phone and have it reflected on the big screen (Figure 5.a). The Figure 5.b shows how a map is rendered from the small screen onto the large display. The display can either show what is exactly on the device or it can show the entire content, thus not restricting the content by the size of the small device. In the example of the map shown below, the user can zoom in and out by physically moving towards or away from the screen or by moving the device sideways to change the location.

Figure 5. Virtual projection by [Boring and Baur, 2013]: (a) The content from the mobile device is projected onto the larger display. (b) The mobile device acts as a "magic lens" where user can interact with the screen by physically moving the mobile device.

The second prototype that Boring and Baur [2013] created to study cross device interaction was called *Touchable Facades* (Figure 6). For this study they utilised the *Touch Projector* [Boring et al., 2010] which allows users to interact with a distant display like a wall projector or desktop screen. The users can point their phone at this distant display and manipulate the objects on the display by touching the objects on the live video feed on their mobile device.

Figure 6. *Touchable Facades* [Boring and Baur, 2013]: by touching the video feed on their mobile device's viewfinder, multiple people can simultaneously change the color of the façade.

For the *Touchable Facades* experiment, in order to study the interaction in a truly public setting, they applied *Touch Projector* approach to a building in Linz, Austria during an arts festival. The users of the tool saw it as a form of digital graffiti and the responses were mostly positive. Some users however, were frustrated with the simultaneous use of the application by multiple users. The tool thus allowed for competitive and collaborative interactions.

Large displays have been popularised with the advent of newer modalities and ways of interactions. They have been found to be more engaging and welcoming when there is an aspect of interactivity added to them. Various modalities like gesture, speech touch and so forth, have been explored by researchers and the results have shown a positive trend towards their acceptance. Using other readily available devices like mobile or laser pointers enhance the possibility of large screens becoming more mainstream. Another facet of this trend is dependent on the domain of use. Large screen displays have so far been used in IT organisation, military services, educational purposes and for general information sharing in public spaces. The next section deals with how users interact in an IT organisation and how large screen displays can facilitate collaboration amongst the employees of that organisation.

3. Collaboration in shared workspaces

Since the 1980s, a number of studies have been carried out in the field of collaborative systems. Many industries in today's world have employees spread across continents and have to interact with each other on a daily basis. Information sharing and resource allocation are one of the major tasks that managers have to deal with. As such, the following section describes one such process called the **Agile RE** which companies around the world have adopted to speed up such tasks. Further sections take up examples from previous research to show how large screen displays can be utilised in such a collaborative set up.

One major use of working with applications for collaborative work, is its ability to record data. In a study conducted by Electrica et al. [1999], they developed a system to measure individual and group behaviour that characterizes collaboration while performing a task. Their system could record all the actions made by the users, the time and date, learning experiences, tasks, type of actions etc. This made further evaluation of data much less complicated. Systems which utilise user logs have been used as a reliable source of information gathering. In industries during audits, many such systems have been utilised to gather relevant data and also to analyse a company's development process and to determine whether it needs a revamp.

3.1 Introduction to Scrum and its features

When studying about how a large screen display can improve collaboration in office settings, it was key to understand the various processes that are currently adopted in the IT industry. This helps formulate designs to incorporate the existing processes and to devise strategies for the betterment of these processes. The Agile process [Ramesh et al., 2010] is an integral part of most software establishments today and the following section explains in depth the evolution, procedure and the roles associated with it.

Agile software development process came into existence as an alternative to traditional software engineering approaches. It was introduced to speed up the system development. Agile requirements engineering (Agile RE) is a set of principles that guide software development processes and is more dynamic and adaptive in comparison to other traditional approaches.

The Agile RE Framework consists of the following. Firstly, it constitutes the needs which in-turn leads to Agile RE practices. These needs include constantly changing technology, evolving requirements and time constraints. The above-mentioned needs, lead to face-to-face communication, prioritization, constant planning, prototyping, iterative requirements engineering and reviews and tests [Ramesh et al., 2010] . Scrum

is one of the many iterative agile software development processes that was formulated by Dr. Jeff Sutherland together with Ken Schwaber [Schwaber Ken, 2004]. In the following section, a brief explanation on how Scrum works is provided and it is further detailed with the help of Activity theory.

As the complexity of a system increases, a centralized control over all the functions may lead to chaos and inefficiency. A decentralized, distributed handling of tasks can prove to be helpful in dealing with this complexity. The analogy of *shipping a package* is given by Schwaber Ken [2004] to further understand this concept. The driver who delivers packages is not dispatched to each house or destination beforehand. While he is on route, the one who is closest to the destination is given the notification. The addresses and deadlines are updated continuously and it is the job of the driver to plot a route that can reach all the destinations in time.

Scrum works in a similar manner. It shifts control from central agents to individual teams thus delegating work and subsequent decision making to those independent teams. Scrum works in increments, which becomes essential especially in today's market scenario where requirements are subject to constant changes depending on the market shift. Scrum is built on a 30-day incremental cycle thus shortening the feedback loop between the developer and the customer. The team and the product owner reaches a consensus on what can be done in 30 days' time and the focus here would be on high priority tasks and the value of its delivery.

Another advantage of this decentralized approach is that it allows team members to take up a task and figure out a way to accomplish it on their own by using their creativity and detouring around any roadblocks that they may encounter. This may not have been possible if the tasks were centralized and individual members did not get the opportunity to voice their ideas on challenges faced. Scrum empowers individual team members that result in the delivery of a quality product, which in turn leads to satisfied customers.

How Scrum Works

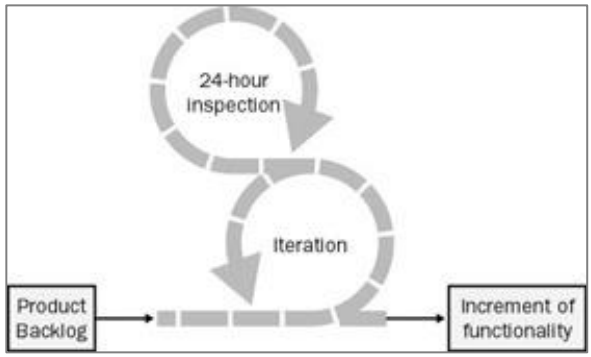

Figure 7. Scrum Skeleton [Schwaber Ken, 2004]

Iteration is the keyword when it comes to scrum processes. The scrum skeleton is depicted in the Figure 7. The lower loop indicates the development process and each iteration produces a product output. The upper loop denotes the inspection that takes place on a day-today basis in order to evaluate this product output. As mentioned before this cyclic inspection makes sure that the requirements are met with a certain level of completeness. The team evaluates the requirements given by the customers, makes a plan about what can be done in the first cycle and assigns duties. Considering the resources like manpower, available technology and skills, the team arrives with a plan. At the end of each iteration, the output is presented to the customer who then evaluates it and gives necessary feedback.

Scrum Roles

The three Scrum roles are: The Scrum Master, Product Owner and the Team.

i) The scrum master is responsible for keeping the scrum process intact. They make sure the rules are being followed systematically and the scrum is being implemented.

ii) The product owner represents the interests of all the stakeholders involved with the project. They create the *Product Backlog* which lists the requirements. This list is constantly updated based on the priority of the functionalities and the high priority ones are built in the first iteration.

*iii)*The team takes input from the product owner and the scrum master and comes up with solutions for the development of these functionalities and makes sure the output is ready by the end of each iterative cycle.

Scrum Process

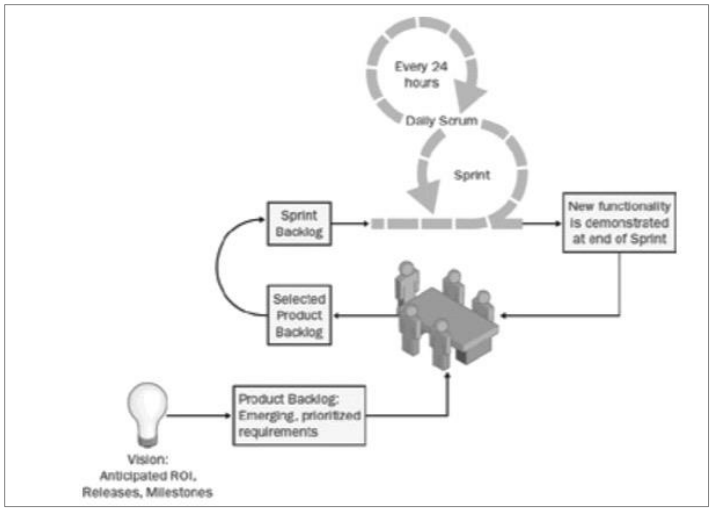

Figure 8. Scrum Process Overview [Schwaber Ken, 2004]

The scrum process (Figure 8) is executed within time constraints called *Sprints*. A sprint lasts 30 days and begins with a *sprint meeting*. Here the product owner and team discuss what needs to be done in the next scrum, selecting high priority functionalities from the product backlog. During this meeting, the team evaluates the said functionality and provides information on how much can be completed in this particular scrum. This is usually a tentative plan and is subject to changes based on a number of variables. The agreed upon tasks are catalogued in the *Sprint Backlog*. A daily scrum meeting is held for 15 minutes where each team member describes what he has done since the last daily scrum and what he plans to do for before the next. Any issues that he may encounter are also discussed. The purpose of this meeting is to keep all the team members up to speed about each other's progress. At the end of 30 days, sprint meeting is held where the team presents the developed functionalities before all the stakeholders. The scrum master holds a retrospective meeting at the end in order to evaluate the implementation scrum process and provides inputs on how to improve for the next sprint.

Scrum analyzed with Activity theory

Activity theory is a conceptual framework devised originally by Leontiev et al. [1978] who was a psychologist from Russia. Further revision of the theory was later on done by a Finnish educational researcher Engeström [2001]. In a broad sense, activity theory can be stated as an interaction between two entities, where these entities could be an 'individual or a group' and the outside environment, and where one entity fulfills its

needs through the other. Here the ‘actor’ or the human being is referred to as the **subject** and the **object/motive** is the task at hand.

Concepts of Activity Theory

In the following section, we dwell deeper in to the principles and concepts of Activity theory and analyze them based on examples obtained from the analysis of scrum.

Object-orientedness: This is the most important principle of Activity Theory as it structures the entire framework. The object as mentioned above is the task at hand. This task determines the actions implemented by the subjects. The actions of the actor or the subject revolve around the manipulation and implementation of this task. An example of an object could be “Assign duties to the design team”. Here the individual using the Scrum tools is the subject. How he goes about implementing the process and interacting with the outside environment to conduct this task is the **activity**.

Hierarchical Structure of Activity: Leontiev et al. [1978] proposed that activities take place in hierarchical levels and that one action leads to another. The final task completion could be one of these sub level tasks or it could be the final task. The result obtained will therefore be a culmination of all the sublevel tasks. Each action is carried out in-order to fulfill a final objective or motive. For example, an individual may check out the *product backlog* to determine the priority tasks for the current sprint. The final motive could be to complete the activities of the Sprint on time.

Internalization and Externalization: According to activity theory, internal and external actions go hand in hand. One cannot be analyzed without the other because humans tend to constantly transform their actions from internal to external and back. An example of an internal activity could be to be familiar with the skill sets and problem areas of the members of a team. This information is learnt and stored in memory in the initial stages and when the individual is searching for a member to assign a high priority task, he can choose easily. This decision-making as to which member to choose based on the type of requirement is automatically made in his head without giving much further thought. That internal decision is then externalized in the form of updating the scrum board with the tasks and the members assigned to each one.

Mediation: In Activity theory, mediation is mainly discussed with respect to tools and culture. First, we will discuss about tool mediation in our case scenario. Tools refer to artifacts that are being used by an individual to perform a particular task. For example, the *product backlog* is used to list down the requirements and form priorities. These are the external tools. The internal tools that also being used here are the user’s previous

knowledge of the various scrum processes and its implementation. For a person who is new to the project, he would have to find out what tasks have been assigned to him and figure out a way to participate in the scrum process. Thus, knowledge as a tool is an important entity, which can determine the flow of action of the user. We compensate for our lack of knowledge by employing mediating artifacts, which can be internal or external, physical or immaterial [Kaptelinin et al., 1999].

3.2 Large displays in collaborative meetings

An integral part of all meetings is a medium for participants to share ideas and information. Several studies suggest that the numbers of meetings being attended by people have been on a steady increase. In a survey conducted by Tobia and Becker [1990] , they found that more than 72% of the 1900 business leaders who participated in the survey, spent more time in meetings than 5 years before. In such scenarios, in order to understand how a computer supported environment can be utilised to make meetings more collaborative and efficient, an experimental meeting room known as *The Colab* was set up at Xerox [Sibley et al., 1987].

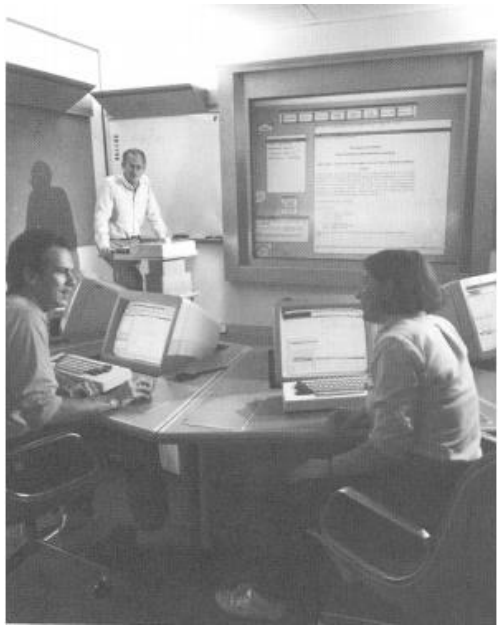

Figure 9. *The Colab:* an experimental meeting room set up at Xerox [Sibley et al., 1987]

The Colab shown in the figure above (Figure 9) was the meeting room set up that was designed for 2-6 people. Each participant had personal computers which were linked together over the LAN. The room was also equipped with a large touch sensitive display and a stand-up keyboard. The system supported multi user text entry and thus participants could write-in their brainstorming ideas to the screen at the same time. This enhanced flexibility and discouraged control of the activity by one person.

An experiment conducted by Hawkey et al. [2005] studied how proximity can impact the effectiveness and enjoyment of collaboration. The experiment was conducted with the following cases: *i) both near ii) both far (iii) near/far with direct input (iv) near/far with indirect input* (Figure 10). Direct input here meant, the user far from the display used a synchronised LCD tablet with the screen available and indirect

input meant the user far from the display used a tablet with no display thus making his input “indirect”.

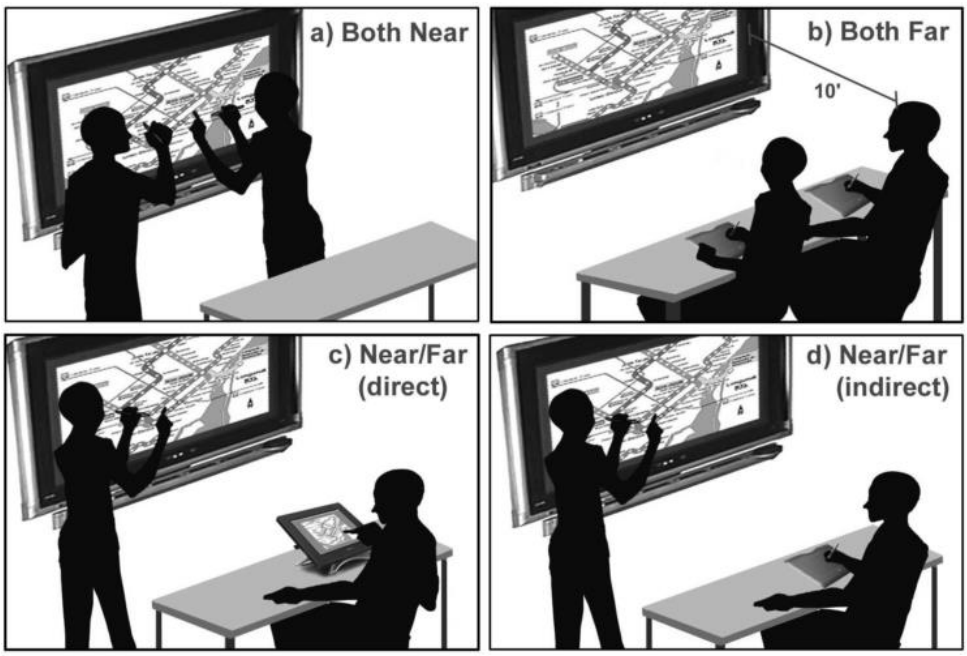

Figure 10. Experiment use cases: a) both near b) both far (c) and near/far with direct input (d) near/far with indirect input [Hawkey et al., 2005]

The results of the study suggest that users preferred to be placed in close proximity to each other while performing a task and also the interactions with the large display was more effective when they were closer to it.

Coming to more recent years, the Microsoft Surface Hub [Hofmeester and Wixon, 2010] and Google’s Jam Board are the more recently commercialised collaborative tools that are available in the market. The main interactions are performed with a stylus or just with the touch of a finger. One important feature they offer is that it allows connection to a shared cloud space where all the data you enter is saved in real time. The trend to be noted here is that as more such commercialised tools hit the market, the users tend to be more accustomed to larger displays being around them and as such begin to expect certain general standards in terms of interacting with such displays.

4. Stage 1: Research, analysis and initial designs

In Stage 1 we discuss in detail the processes, methods and observations made in order to understand how team collaborations can be improved with the help of a large screen display. In order to gather information on how an actual team operates within an office environment, a study was conducted at a software company in Tampere, Finland. The following sections will give a clear picture on the process and the outcome of the study.

4.1 Methods

The method section describes the steps and measures taken to conduct the study. It gives details of the company, the participants who were interviewed, and also the reasons for choosing this company and this particular set of employees.

4.1.1 Company

In most office scenarios pertaining to a software development company, a team will consist of a project manager, lead engineers, software engineers and designers who may be *on-shore* or *off-shore* employees depending upon the scope of the project. The Finnish software company chosen for this study handles clients from around the globe and implements projects based on the SCRUM model. For this study, 7 participants who held various positions at this company were interviewed.

4.1.2 Participants

The interviews were held with six male and one female participants as a **qualitative study**. Four of the participants were natives of Finland and three were from a foreign country. The employees were chosen based on their previous experiences with working in international projects. This was intentional because one of the areas this stage of the thesis seeks to explore, is how team members communicate with their counterparts abroad.

4.1.3 Procedure and Materials

The interviews were conducted within the office premises over a span of two days. Each participant was briefed on the purpose of the study and was asked to sign a consent form given in Appendix 1.i.. The interviews spanned an hour each and the sessions were audio recorded. Talking to employees in their own work environment lead to more honest and open discussion in a way that when discussing a topic related to work, they could relate to the question more as it was easily identifiable when they were in the same office premises.

The interview questions provided in Appendix 2.i were set to obtain an overview of the kind of work the participants were involved with and how the collaborative work amongst them can be improved. The first section of the interview questions aimed to

gather details on their tasks and responsibilities and how they interacted with their co-workers on a daily basis to facilitate these tasks. The next section focused at a more personal level to see the different modes of formal and informal interactions that take place and what boundaries were set in terms of information exchange. These questions helped in understanding the needs of the employees and to get ideas on how to improve their day-to-day work processes. The final question was more direct and sought to learn what employees would like to see on a large screen display if it were available in their office.

In the next part of the interview, participants were presented with 5 prototype sketches made for large screen displays in an office environment. Further discussion about these sketches have been provided in Section 4.2.1 of the thesis. These sketches were based on various scenarios like *when a meeting is in progress*, or *an example for a team building activity*. The most relevant scenarios were presented to the participants. The sketches were presented one by one as a means to provoke more ideas from them. The order of the sketches shown to each participant was chosen with a random number generator. Each sketch was presented to the participant and they were given a brief overview of the scenario. The participants were then encouraged to share their thoughts on the sketch and the idea as a whole. This task was helpful in figuring out what information was most essential and what could be eliminated or improvised with. It also led the way to discovering a number of new ideas and scenarios for large screen displays, the details of which will be explained in the coming sections.

4.2 Analysis and Results

The data gathered from the interview sessions and the audio recordings were then analysed with the help of the *Affinity wall* technique [Beyer and Holzblatt, 1999] . All the key points gathered from the interviews were noted down on sticky notes and they were put up on the wall. Some set categories were already in use such as *communication with people abroad vs communication within the office*, or *comments on each sketch*. As the process progressed, further sub-divisions were formulated. For e.g. the comments on the sketches were categorized into *what an individual requires vs what the team requires*. This helped in analysing and categorizing inputs from the participants effectively and to simultaneously get an overview and an in-depth view of the information gathered. This process helped in revealing patterns and relationships between key themes and in recognizing reoccurring themes.

The following are the categories and the information gathered from the interview sessions.

1. *SCRUM meetings:* During the daily SCRUM meetings, the employees who are part of a team, discuss what tasks are currently going on and what they have done since

the last meeting and if they faced any issues with their particular tasks. They also discuss what task each person is responsible for next. These meetings are not extensive discussions but are done to seek short descriptions to get the gist of the idea. SCRUM matrices and process tools like Confluence are used to determine the progress of the project. These daily stand up sessions usually take place at a fixed time.

2. *The project:* When in a project, the employees need to know about the current sprint, the features that they need to develop, the specifications of the project, about the tools being used, the licenses of various tools and details of external dependencies if any and how to deal with them. They were also interested in knowing about additional information that may come from the client as the project progresses, about the project related documents that were not available in the public domain and how to access them. Another key information that they required was, to know about the tasks and progress of their team mates and how they could contribute to its development. In some cases, depending on the kind of projects, the team initially studies certain devices and tests them for specific functionalities. Reports are created based on this study to determine whether a case is promising enough to be continued or not.

3. *Current tasks and resources utilized:* Each team member works on individual cases, and works privately in peace. They refer to the main source document provided by the customer, which is obtained from the public domain, various internal documents with information about specific technologies, their common features and functionalities. They receive project reports, comments and feedback from customers and managers via email to help them with their tasks. In projects working with the SCRUM model, the team members also refer to the product backlogs and process tools. They utilize software configuration managements tools which creates software builds and integrates different items into the build and manages it.

4. *Peer-to-peer interaction:* Team members interact with each other via emails, face to face meetings and during the *daily stand-ups*. Sometimes when an issue occurs, they start discussing about solutions right away without waiting for a scheduled SCRUM meeting. They are accustomed to seeking knowledge from a person who has already studied about that technology which they are working on but there is also a general lack of understanding about the skill level and domain expertise of their counterparts. They also turn to topic-specific channels in instant messaging forums in search for an answer when they are faced with a technical issue.

Unofficial discussions also take place in the coffee rooms and during lunch hours. Summer parties and office get-togethers are made use of, to conduct surveys and receive feedback from employees regarding the current work set up. These get-togethers also help in ideating new strategies and in getting to know each other in a better way.

Outside of the team, the employees would like to know what technologies/projects their peers are working on and if there are any opportunities for them to participate in. They would also like to know each other's previous work history, so that they can seek help from an expert on the topic when needed. Knowledge of each other's current whereabouts and access to each other's calendars would be helpful in this scenario. Interactions with customers happen over email, face-to-face meetings or via a designated lead engineer who speaks on behalf of the team.

5. *Overseas projects:* Most overseas projects with this particular company were collaborations with teams in India and China. Regular meetings via Lync, interactions via email and instant messaging, telephone and screen sharing applications etc., are the means of communication used. Depending on the projects, some team members also travel to these locations to oversee the work. These modes of communication help in discussing and implementing functionalities and also gives an opportunity to learn something from each other.

   There are however, many issues that may occur while handling overseas projects. One participant commented that an improper usage of SCRUM can lead to certain difficulties in managing teams and deadlines. This can happen when the Scrum Master and the team are both in two different time zones. When interacting with people from other countries, it is essential to be acquainted with their work habits and working times. This helps to effectively sync up meetings and to bring better productivity to the work. Learning about their counterparts abroad also helps in understanding the issues they face for e.g. any health issues that may interfere with work. Knowledge about such situations help managers in coordinating and assigning work accordingly.

6. *Cultural differences:* Cultural differences are important to understand and respect for a project to run smoothly. One such difference is how people from different countries handle a pressure situation. When asked about the cultural differences, one Finnish employee mentioned that Finns are not ashamed to admit a mistake or admit when they do not understand something as opposed to their Indian counterparts who sometimes pretend everything is alright when it is not and does not acknowledge the situation until their managers are cc'd in an email. This could

be because of the cultural differences in upbringing and also due to the innate need for Indians to be polite [Lewis, 1999]. In a study conducted by Alfons van Marrewijk [2010] comparing the Dutch and Indian way of working, it was shown that Indians found it difficult to say 'No' and that they would perceive an interaction to be good, if it was polite and without conflict. On the other hand, the Dutch preferred a blunter approach without ambiguity. Although this kind of generalized information is prejudicial and should not be the first thing you learn about a culture, it is also important to understand the thought process behind each action.

Another barrier mentioned by the participants when it came to communication is the English language not being the first language of either parties involved. Two participants mentioned that this has led to frustrating meeting calls and video conferences where asking to repeat more than once, could seem impolite. All of this may lead to a hindrance in communication which in turn causes a lack of visibility for managers to understand how the overseas team is progressing.

7. *Exchange of personal information:* While some participants wished to know more about the personal hobbies and interests of their team members and counterparts both here and abroad, a few of them held to the opinion that only certain information about themselves may be revealed. For e.g. birthdays or relationship statuses were not favorable information that they were too keen to be made public. They however, were interested in sharing their areas of skills and expertise, and about their current and previous projects. They were also keen to know the technical knowledge of other individuals, the number of people who would be interested in attending a teaching session if they wish to conduct one, about the other activities they do within the organization, their availability at work at a certain point in time, their leave schedule and so on. The emphasis was more on work related topics rather than personal information.

8. *The sketched prototype ideas:* The sketches were designed for large displays that can be public, semi public or private. These sketches were presented to the participants one at a time and were asked to share their opinions and further ideas on it. In the description below, each of the sketches and their artifacts are explained in detail. The comments and thoughts brought forth by the participants and their implications are discussed here.

4.2.1 Preliminary sketches and feedback

The following section now describes the sketches made for the interviews and how the participants responded to each one.

Screen 1: Main screen with meeting and weather information

The main screen design (Figure 11) was done for a large screen display which will be displayed in a semi-public area of the office. The users will get a quick glance of the meetings scheduled for the day. It also provides contextual information on weather, time, the countries and cities that the company has branches in or does business with. It also gives exclusive details about the next meetings scheduled and the list of participants in each. Each section can be navigated with a left/right swipe gesture.
Each vertical section consists of the following data:

a) Name of the city, current weather and time
b) Countdown to the start of the meeting
c) Agenda of the meeting
d) Personal information of a participant or details of an event (like a birthday or a cricket match)

Feedback: Two of the participants felt that the weather information in Figure 11 was taking up too much space and that the focus should be more towards the meetings and the upcoming events. Another participant however felt that discussing about the weather adds a personal connection. One important comment that came through was that the agenda may not always be public due to confidentiality agreements with clients and hence should not be displayed on a semi-public display. Other suggestions that the participants proposed that could be included was to show the electricity and water usage of the company to prompt employees to use these resources judiciously. One participant suggested that the screen can be converted into a live streaming display to stream conferences like CHI that take place around the world. It can also be used to display activities happening in other work sites which can be switched based on a timer. One participant mentioned that once in a while, the company organizes get-together's in an attempt to encourage employees to suggest new ways to improve their work experience. For such exercises, this display can be utilised to provide feedback from the employees.

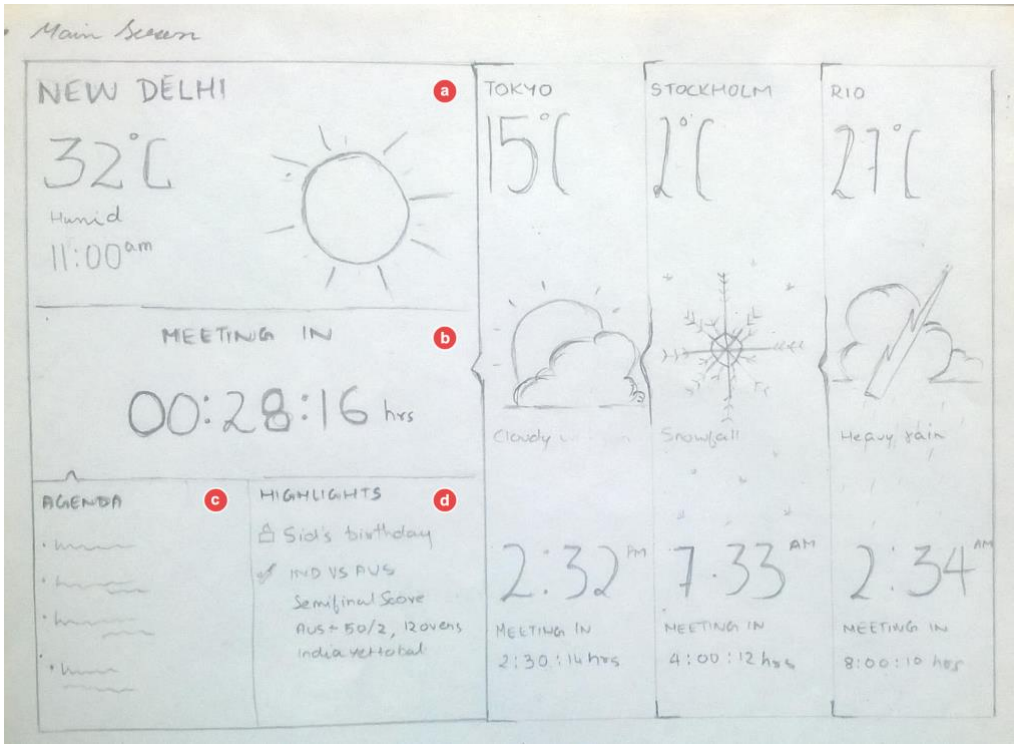

Figure 11. Main screen: (a) name of the city, current weather and time (b) countdown to the start of the meeting (c) agenda of the meeting (d) Personal information of a participant or details of an event

The screen can also display general information such as reminders about deadlines of entering reporting hours in the system, lunch menus, special weekday menus etc., which basically mimics a notice board.

In a real-life scenario, multiple meetings take place simultaneously and information pertaining to each meeting, like the meeting room number, the participants attending it, the scheduled time, information about reserving rooms and the availability of free slots can be added. Currently, the common space in the office consists of a legacy computer system with a desktop screen which displays information. This current system in use was remarked as cumbersome and unattractive and such drawbacks can be tackled with this new design for a large screen display.

Screen 2: Video conferencing screen

The screen design shown in Figure 12 is for a private display screen which will be displayed in a conference room. This particular screen shows a video call in progress. It gives details about the meeting like the agenda, it's participants and the relevant documents. It also depicts information such as the live score of a sporting event which can act as an ice-breaker before the start of the meeting.

The features of this screen include the following:

a) Agenda of the meeting in bullet points where each point will be marked with a tick after it has been discussed.
b) General information about the person/people in the video call
c) List of other participants taking part in this video call
d) Documents that are relevant to this particular meeting.
e) Option to share a document with the whole group or with one particular person.
f) Any significant update regarding the live sporting event will be displayed at the beginning or end of the meeting.

Feedback: The ideas that came forth from this particular sketch proved to be of extreme importance in the next stages of the thesis. Majority of the comments from the participants were regarding how they would customize this design to their own needs and said that in a real-life scenario, the functionalities should not be forced. They were of the opinion that functions like displaying the live score of a sporting event might take away the attention from the meeting and thus can be either shown in the beginning or the end of a meeting if necessary. The live score function was added as a means to an *ice-breaker*, before the start of a serious meeting.

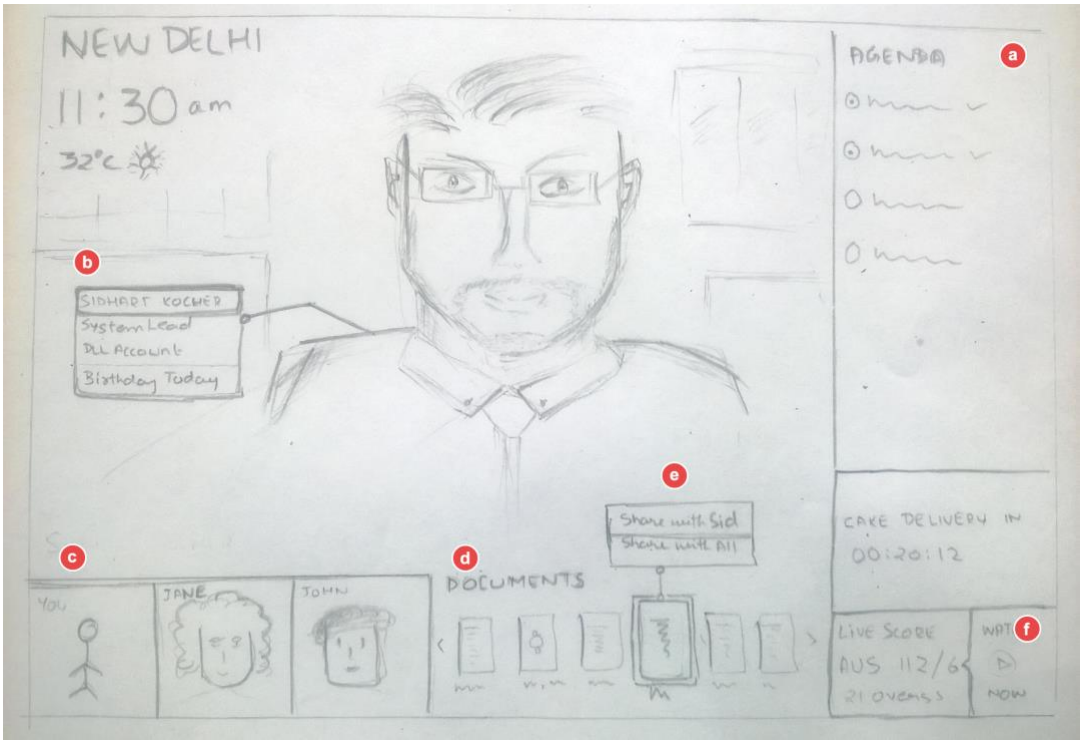

Figure 12. Video conference screen: (a) agenda of the meeting in bullet points where each point will be marked with a tick after it has been discussed (b) general information about the person/people in the video call (c) list of other participants taking part in this video call (d) documents that are relevant to this particular meeting (e) option to share a document with the whole group or with one particular person (f) any significant update regarding the live sporting event will be displayed at the beginning or end of the meeting.

Another interesting observation from one of the participants was that during meetings, when a document is being presented, he would like to get a feedback from the people viewing it, as he would, if they were talking face-to-face. Thus, the question of whether the document being presented should be on the main middle section of the screen or the actual video feed, arose. Regarding the resources of the project, one participant said that an option to view previous history about the callers like emails, messages, previous topics discussed, the documents involved and so forth, would be useful for referencing. Other functionalities like the ability to switch slides, an option to see the time remaining, to have authentication to access this application and restructuring the content to give more importance to the agenda section, were the other suggestions that came forth from the participants.

Normally in a conference call with multiple participants, it is sometimes difficult to identify who is speaking and also to voice your opinion about a topic without

interrupting another person. The solution was to identify and highlight the person with the help of voice recognition, in order to know who is currently speaking. A provision for adding thoughts and comments online would also be useful in this scenario.

Screen 3: Dashboard with timeline

The dashboard (Figure 13) is meant for a semi-public display where teams and managers can view the overall progress of a project. It contains details of upcoming deadlines and other events that are relevant to this particular project which take place on that particular day.

The design also incorporates the following features:

a) The timeline shows the progress of the project. The current month is highlighted and its weekly milestones and deadlines are marked.
b) The pie chart graphically depicts the progress each department has made.
c) The 'Build Progress' shows the progress of the current build which has to be presented for a demo today.
d) The call button enables a manager to contact the team lead on his work phone.

Feedback: The timeline and the progress bar functionality shown in Figure 13 shown below, seemed to be a useful feature especially for project managers who handle high level operations, to quickly gauge the progress. One participant suggested that the section on the left can also display major tasks that have been completed, highlight when a task has taken more time than expected and show reasons for it. Other ideas for this section included display of errors, issues being faced, bugs occurring and information about the current iteration of Sprint. The bar graph or pie chart can show how much has been done and how much can be completed based on the current pace. One suggestion was to derive this progress directly from the Scrum Matrix which has information about tasks left in the backlog and can calculate the time required based on the current velocity.

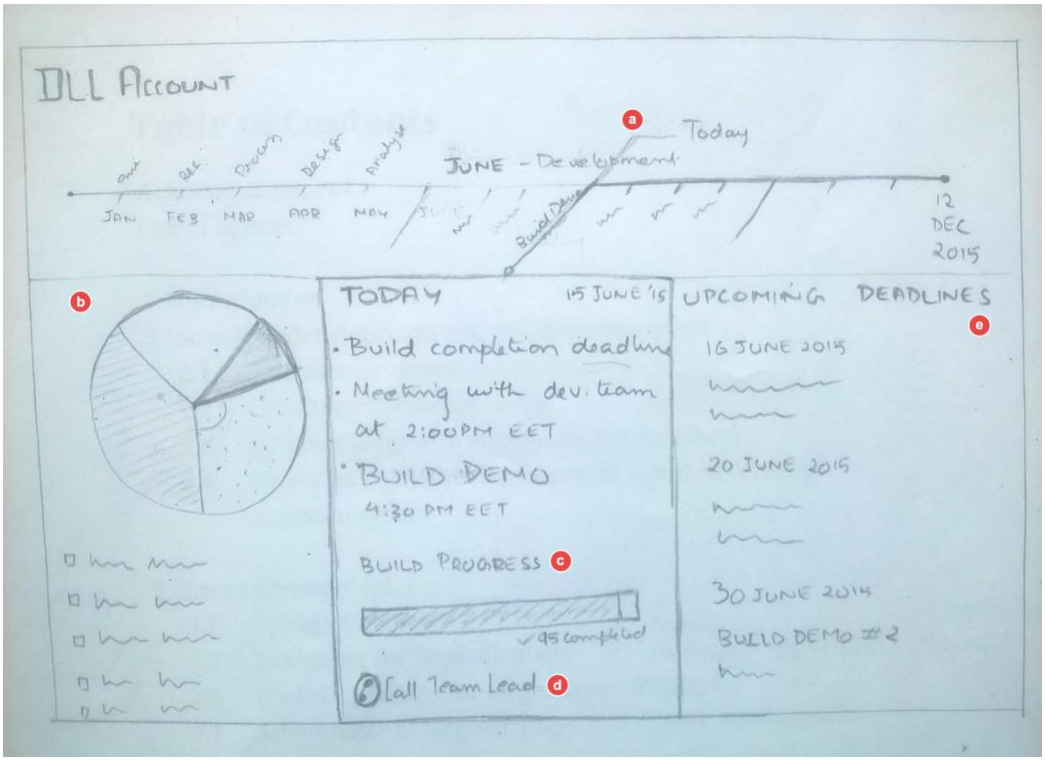

Figure 13. Dashboard with timeline: (a) the timeline shows the progress of the project. The current month is highlighted and its weekly milestones and deadlines are marked. (b) the pie chart graphically depicts the progress each department has made. (c) the 'Build Progress' shows the progress of the current build which has to be presented for a demo today. (d) the call button enables a manager to contact the team lead on his work phone (e) Upcoming deadlines

In case of large software projects, where builds take a long time, the 'Build Progress' can also depict a common built program that can be useful for all team members. The display can also show information about the availability of team members i.e. whether they are on leave or have taken a half-day off or about who is working on holidays. The application can be synced to the calendars, databases and shared document drive without flooding the screen with too much information.

Screen 4: Upcoming events and live feed of festivals

This screen (Figure 14) was designed as a means for people working in different cultures to get to know each other better. It shows information about upcoming cultural and other events from all the countries the company has a collaboration with. It gives a space for displaying pictures and videos from past years' celebrations. The display can also broadcast a live event that your colleagues are attending. It can also include information about technical events and conferences happening around the world.

Feedback: The idea of live feed and history of pictures and events were well received amongst the participants. This functionality of displaying the co-worker's birthday was however not received with much enthusiasm as many of the participants revealed that they would prefer to not have their personal information made public. One participant commented that information about important festivals, or holidays in other countries would help to know if it is a working day or not and can explain why there hasn't been any reply to emails on a particular day. Another idea that came up from one of the participants was to feature a contest where they can upload pictures directly to the application while in the coffee room and allow other employees to cast their votes using an NFC tag or bar code.

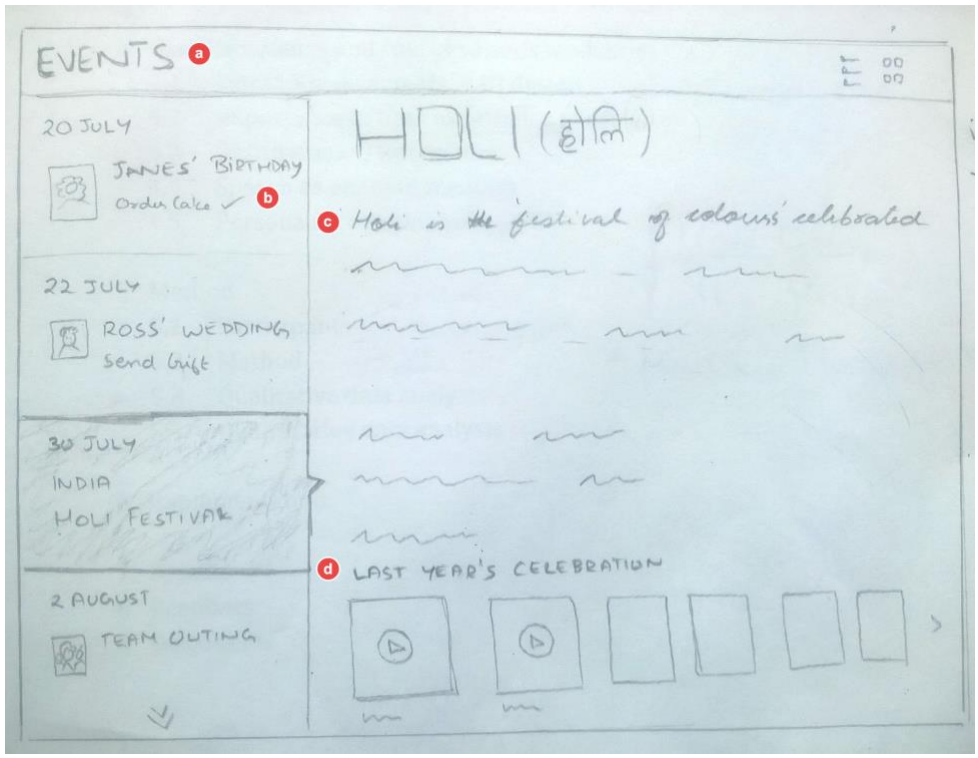

Figure 14. Upcoming events and live feed: (a) list of events (b) action point indicated by tick mark after it has been executed (c) a brief description of the selected event (d) videos and pictures from previous year's celebration

Screen 5: The Game Screen

The purpose of this design was to bring employees who work in different stations together to perform a leisure activity. It would enable them to communicate with each other via the screen and to subsequently build relationships with their counterparts abroad. The design below in Figure 15 shows a 'paper-mache competition' where opponents are from different cities and they are given the same task to complete. The player can view the opponent and their progress.

The design incorporates the following:

a) Countdown timer
b) Step-by-step instructions
c) Preview of the opponent and their progress
d) Overall score
e) Personal progress in the current game

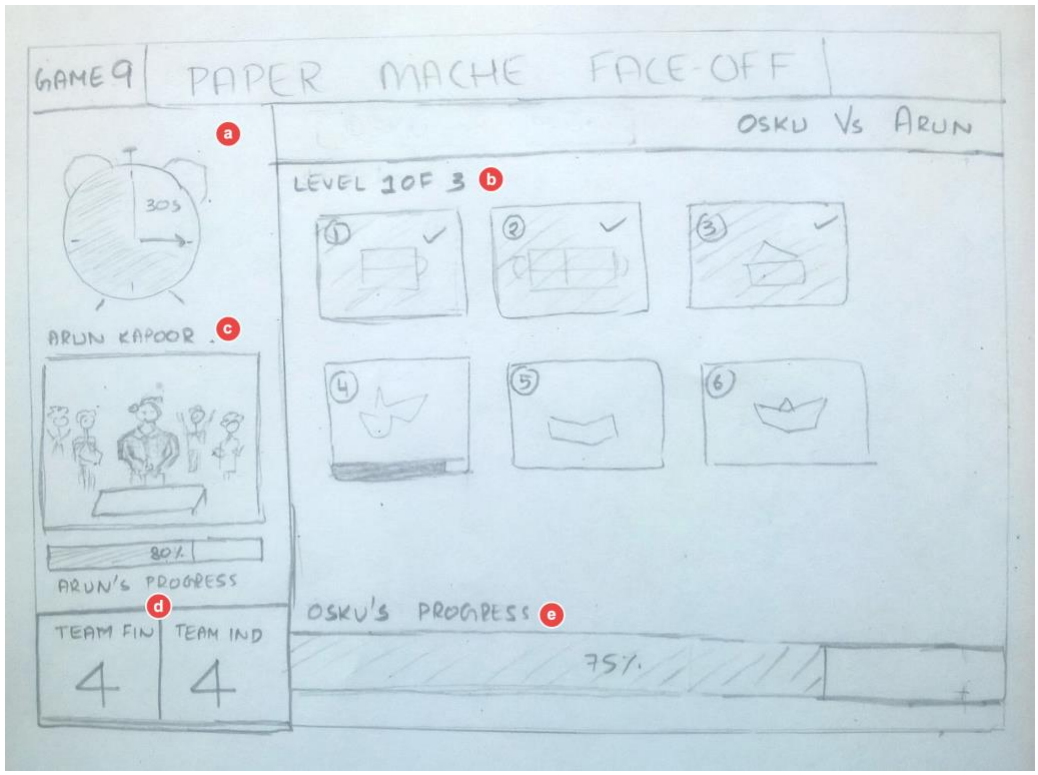

Figure 15. Game Screen: Countdown timer (a) countdown timer (b) step-by-step instructions (c) preview of the opponent and their progress (d) overall score (e) personal progress in the current game

Feedback: One major concern from the participants who reviewed this sketch was the difficulties in arranging an event such as this between their busy work schedules. They were also not keen on the idea of having to compete with their own team mates and suggested that it could be held between two different project teams. Also, it was suggested by an employee that participation for such events should be voluntary and not compulsory. This point was reinstated by two other participants who stated that they would not have much interest in taking part in such an activity.

One of the alternative ideas was to utilize this design as a source of communication and to have a video discussion on a certain technical topic which could be useful for both sides. When asked about other gaming ideas that they would like to take part in, the response was to have a display for the progress made by all teams in their response to an internal survey such as an employee satisfaction survey. Depicting the progress of this in a competitive way would encourage team members to complete a survey with more vigour. Other suggestions from the participants were to hold the final round of the network gaming that takes place internally, or to have a bicycling completion over the summer which would display the kilometres each team has covered.

4.3 Implications of the interview data

The information and insights collected from the interview sessions were translated into refining the designs for the display. When analysis of the data was done, the ideas and suggestions made by the participants formed two categories. One being ideas for the **individual participants** and the other being common ideas for the **team**. Details of current projects, documents involved, upcoming events, meetings and deadlines were important to the individual. Progress of a project, history of communication, details of meeting rooms, agenda of a meeting, list of participants, and so forth, were important elements to the team. The next step was to narrow down to a scenario which could accommodate the most important components from the above list and thus it was decided that the '*Meeting Room*' scenario would be apt for this purpose.

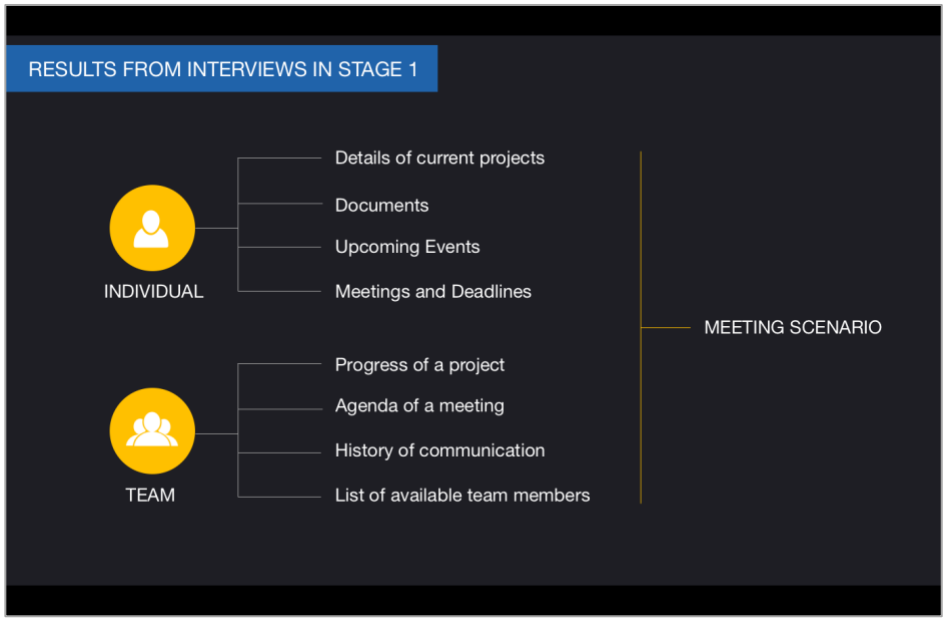

Figure 16. Results from the interviews and how we arrived at the *Meeting Scenario*

Based on this reasoning, the designs were modified and adapted to one screen. The following section explains the design choices for this screen and their implications.

Design for a meeting room display before the meeting commences

Figure 17. Main Screen: A meeting room display designed to show various information that would be interesting to the participants before the meeting begins.

This screen (Figure 17) will be displayed before a meeting takes place, when the participants arrive and settle down at their desks. The screen can initiate dialogue

regarding the current project and its topics and also about more informal topics such as an event that is taking place in that city, or the birthday of a colleague. The display would update on a real time basis and a designated team head could have admin rights to add/remove information.

The screen is divided into sections for easy viewing and also grouped in accordance to relevance and type. The assumption made is that the participants in Tampere are going to have a meeting with the team in New Delhi and each have a similar screen set up in their respective offices. The participants may be seated around the screen facing it or can be standing. The following section deconstructs each part of the design.

Main section of the screen

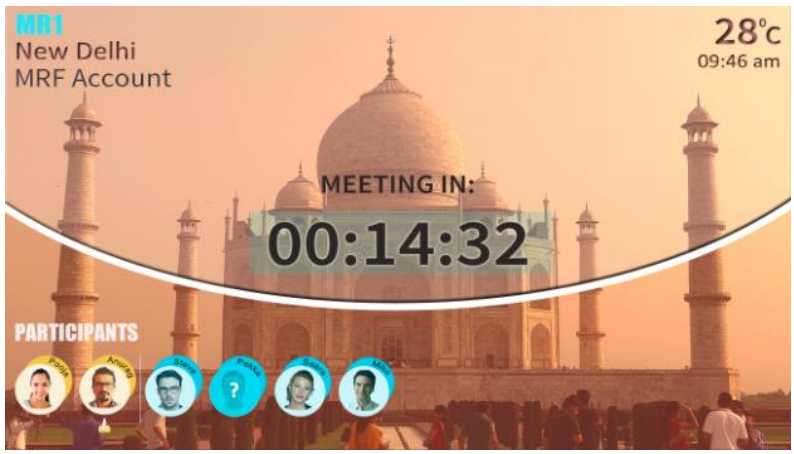

Figure 18. Main section in focus

This portion of the design shown in Figure 18 is where the live video feed of other participants will be displayed when the meeting begins. It will also display documents. This section currently shows:

- name of the meeting room
- name, time and temperature on the city the meeting is being held at
- name of the project or account
- time left for the meeting to start
- list of participants
- additional info about the participants (for e.g. Birthday)

The participant list is colour coded with a particular colour denoting a city. Here the colours blue and mustard have been used for Finland and India respectively. The

participants are denoted as online when their presence in the room is detected with the help of RFIDs. The employees can have tags attached to their employee IDs which can be detected by the RFID reader at the meeting room entrances, when they enter or exit it.

Project status and Documents

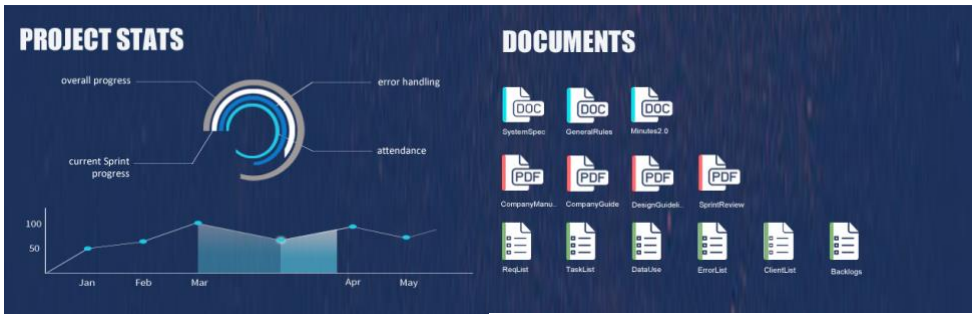

Figure 19. (a) project status (b) documents

The ‘project stats’ section shown in Figure 19.a depicts a graphical overview of the current project. The circular visualisation depicts the progress of the various elements that are instrumental to the project. The x coordinates show the months and y coordinated show the percentage of work done. The graph highlights the duration of the current and previous Sprints, which are relevant to this particular meeting. It also shows the percentage of tasks completed during this period. It is useful to see at a quick glance, which week/sprint-cycle was weak and which week the work was successfully completed. The interface can also show each individual’s progress, the progress of a core-team (for e.g., the UI design team) and also the overall progress.

The documents relevant to this project, the current and previous sprints and those listed in the agenda are displayed in the ‘documents’ section of Figure 19.b. The users can pick a document and choose to share it with all the participants and also view it on the screen. The documents are ordered according to their type.

Agenda and Other Meetings

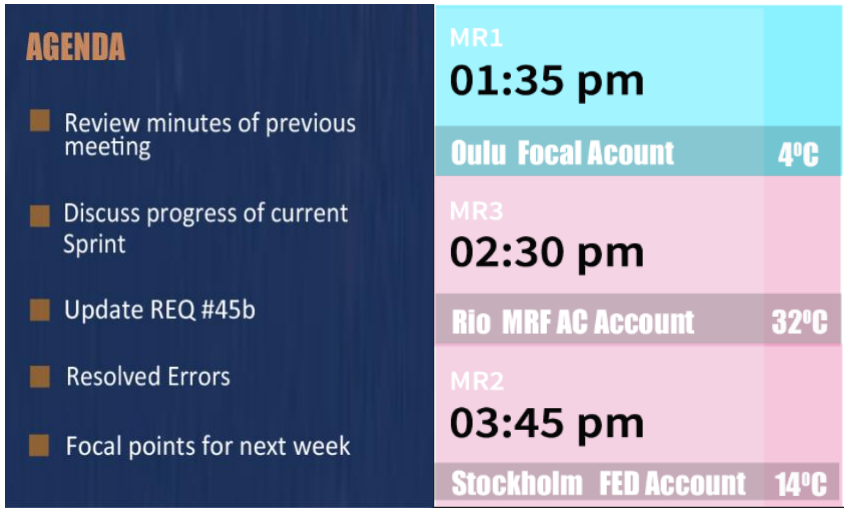

Figure 20. (a) agenda (b) other meetings

The ‘Agenda’ section shown in Figure 20.a lists down the agenda of the meeting. When each topic has been discussed, the text fades to a lighter colour highlighting only the remaining topics on the list.

The meetings section in Figure 20.b shows details of the other meetings that are going to be held during the day where one or more of the current participants are taking part in. This is displayed before their current meeting so that they can plan their schedule in case of an overlap.

History and Highlights

Figure 21. (a) history (b) highlights

Figure 21.a. shows a word bubble that can be rotated, which holds information about the most frequently discussed topic from the previous week's emails and other means of communication amongst the team. The word bubble is designed in such a way that the size of the text varies depending on the popularity of a topic. That is, the most popular topic will have a larger text and so on. Once the user chooses one of the topics, only emails related to that topic will be displayed.

The 'Highlights' section in Figure 21.b gives details of upcoming/on-going events happening in the other country and about the team members.

Design for a meeting room display during an ongoing meeting

Figure 22 shows the second screen, which will be displayed to the team members when the meeting has begun. During meetings with overseas clients or teams, several documents pertaining to the topic are exchanged. As discussed before, one of the participants wanted to see how people react to a document and how it would be interesting to get an unofficial feedback right away. Whereas, another participant wanted to view the documents related to the meeting on the big screen and suggested that the video feed could be faded behind when the document is being viewed.

Figure 22. Meeting room display when the presentation begins

This dilemma between showing the video feed and showing documents on main screen has been solved in the following way. The main section would have the live video feed but when a document or presentation has to be viewed by everyone, it can be posted to the main section and it will simultaneously open in all the screens in both cities. When this happens, the live video feed would move into the rightmost column as shown in the image in black.

The participant who is currently speaking will be detected and his "icon" will pop up for a few seconds, in order to notify all the users. In meetings with a large number of people, it would be useful to get a better idea of who said what. The blue curve indicated in Figure 22, right below the participants, displays the progress of the meeting and shows how much time is left. This is also shown on the top header. The red area on

the right side of the main screen is where the user can move this document in order to close it. When this happens, the live feed comes back to the main screen.

The screens shown in Figure 17 and Figure 22 are best suited for review meetings as it facilitates a collaborative environment where all the members can actively participate and view the proceedings at the same time. The ability to share documents while having a live discussion on them, helps in a better understanding of the topic, of each other's opinions and the thoughts expressed. This helps in ideation and prompt feedback thus replicating a round table scenario with all the members physically present and each holding a copy of the document under discussion.

4.4 Constraints

While developing a viable working prototype based on the *Meeting Room Screen* design from Stage 1 (Figure 17 and Figure 22), certain technical and physical constraints emerged. One issue was the infrequent occurrence of meetings involving multiple countries and then the confidentiality issues surrounding such meetings. The technical constraints with following the Stage 1 designs were as follows:

1. Retrieving live data from the companies about their projects, employees and day-to-day business, storing and analysing this data and retrieving relevant information was beyond the scope of this thesis.
2. Embedding a Skype like video interface into a browser window had its complications.

As a direct result of this, the decision was made to focus the study on meetings within an organisation where such constraints do not occur. Thus, in next stage of the thesis, we discuss the design decisions that led to alterations in designs of screens in Figure 17 and Figure 22, the subsequent user study, its evaluation and implications and the final results.

5. Stage 2: Creating a prototype and analysing the results

At the end of Stage 1, the conclusion that came through was that the screens would be most useful in the case of review meetings. In such cases, there would be set roles for the participants. For e.g. there could be one team leader, multiple presenters, one or more supervisor and a number of documents to be reviewed. However, due to the technical constraints mentioned in Section 4.4, we decided to narrow down the study to *'Review meeting scenarios within an organisation'*. Hence, the next logical step was to observe two such meetings to get a better idea of what exactly goes on during the process and to figure out any obstacles the participants may face.

In Stage 2, we dwelled deeper into the chosen "*Meeting scenario*" by gathering more data on real life review meetings. The designs discussed in Stage 1, were then modified to accommodate the new findings and a working prototype of the application was created. In the final part of Stage 2, a user study was conducted with a group of participants who used this developed prototype to carry out their meetings. The observations and insights received from this user study is presented in the final part of this thesis.

5.1 Observational Study

In order to gain information on real life review meetings, two groups of 7 participants who were students were observed for this purpose. Both groups had a review meeting for a project conducted within the University of Tampere. The first meeting also had a remote user present who took part via Skype. The participants were briefed on the purpose of the meeting and were asked to carry on their discussion as they normally would. The moderator took the role of a silent observer during the studies. The task of the moderator was to observe the actions of the users and take down notes.

In both meetings, the teams made use of a projector display connected to their laptops. All members were seated. The first meeting started with the team leader presenting the agenda of the meeting and briefly going through each step. He then introduced his team mate who took over the presentation. One of the participants controlled the keyboard in order to switch between slides. The presenter would ask him to go back or forward in the PowerPoint document while handling the presentation. The supervisors would comment on the data presented in the document and ask questions or clarify details from the presenter or from the entire group. One other participant would take down notes as the supervisors give advice on how to improve or how to get over a problem area. While they give comments, the supervisors refer to the print-out of the document in their hand. The switching between presenters take place multiple times

during the course of the meeting and sometimes the laptops are switched to connect to the projector.

The second meeting was similar to the first except that, all their documents were in an online drive thus reducing the switching of laptops. One of the presenters used the mouse pointer to point to certain areas of the screen while explaining a particular point in detail. This particular meeting had a demo to be presented which involved gaze tracking. Hence one of the presenters moved closer to the laptop with the gaze tracker while explaining the system He then went back to his seat and the first presenter continued. At the end of the meeting, the supervisors gave their feedback and the rough agenda for the next meeting. The team members were asked to go through all the comments and ideas put forth during this meeting and to document them for future reference.

Summary of the observational study

The results were analysed by gathering all the notes from the observation study. It was observed that the following scenarios overlapped in both set of meetings and thus called for a need to tackle these issues. The outcome from observing the two meetings that there were six instances where control of the slides was passed from one person to another and transitions between one presenter to the next took place. Documents were the main focus of both meetings and access to them was not evenly spread. While switching between presenters, there was a two-minute delay in setting up of the laptop, dependency on another person to switch the slides and instances where two supervisors were talking simultaneously making it difficult for the person taking down notes to keep up with them. In the next section, we take up each of these problem areas and try to come up with solutions to overcome them.

5.2 Implications of the observational study

The *review meeting* observations discussed in the previous section shed light on a number of issues people face in a day to day life when attending a meeting.

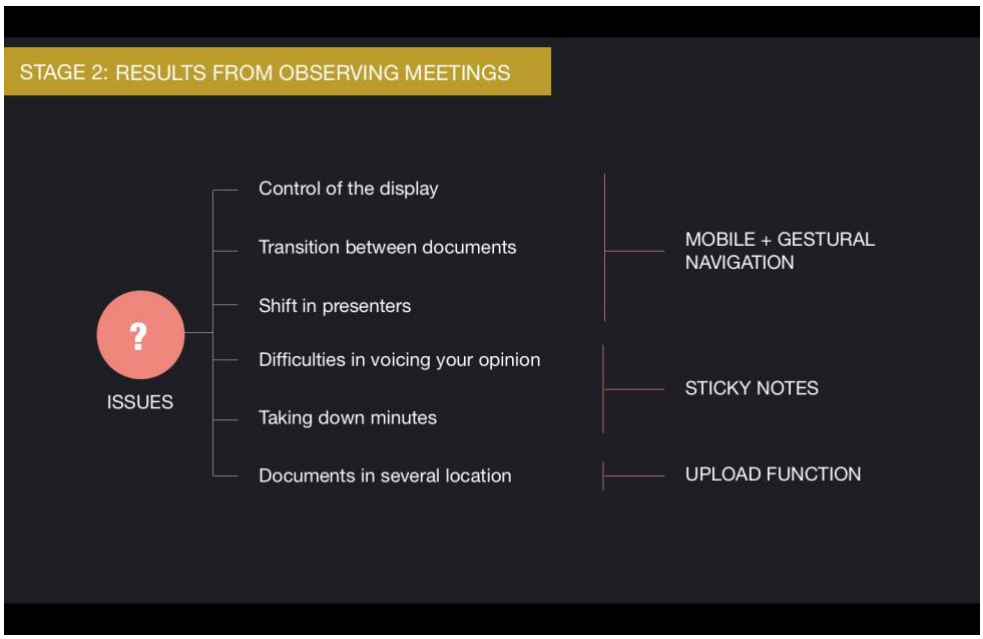

Figure 23. Issues and possible solutions derived from observing meetings

Control of the display was at most times, at the hands of the person with the laptop and not the presenter. This lead to delays in communication where the presenter had to signal the other person to change the slide or to go to a previous page. At other times, when passing over the presentation to the next presenter, another laptop which contained his document had to be plugged in so that the presenter controlled his own laptop to move the slides. Switching seats and devices took up time and sometimes there were issues with the connection or with the adapter which again caused minor delays. If all the documents were in one place and if all the presenters had control of the slide navigation, these problems can be avoided.

In both meetings, there were at least two participants, each of whom spoke very less or not at all. This could be because of the difficulties people face in our day to day lives in voicing our opinion in front of an audience. There are also people who are more comfortable in doing their work rather than speaking about it. A similar issue is connected to the person taking down the notes or the minutes of the meeting. He/she is thrusted upon this responsibility of not missing out on the details and having to document the entire proceeding. This adds unnecessary pressure on one person when the entire group can benefit if everyone took down the important points. This is

because, the likelihood of one person missing an important point is more than the whole group missing it. One solution to tackle both these issues is to have a solution where each group member can type in his opinions and take down notes or important points said in the meeting, which can then be displayed on the main screen for everyone to see. By doing so, even if one person misses or fails to understand a certain key point raised, they can always rely on the team to follow up on it. Another advantage is that; this would also help the "shy" person in the group to actively participate in the meeting.

As a direct result of this observation, the design of screens in Figure 17 and Figure 22 were altered to address these issues and in the following section we discuss the design choices made to overcome each one. A mobile interaction and a *Kinect* based gestural interaction was also created to address the specific problems encountered while shifting presenters, transitioning between documents and passing the control of navigation.

5.3 Creation of a working prototype design

The following are the final set of screens which were created keeping in mind the implications of the observational study. The design consists of two parts: one for the **main display** (Figure 24) and the other for the mobile device (Figure 25) which will be referred to as '**mobileApp'** in the coming sections. The prototype was then tested in the user study that followed. The user study was conducted with three groups that were requested to use the prototype in their meetings. There were two parts to the design as mentioned; one for the large screen and one for the mobile device.

The designs for the large display is as follows:

Meeting room display- as a modification of the initial design in (Figure 22)

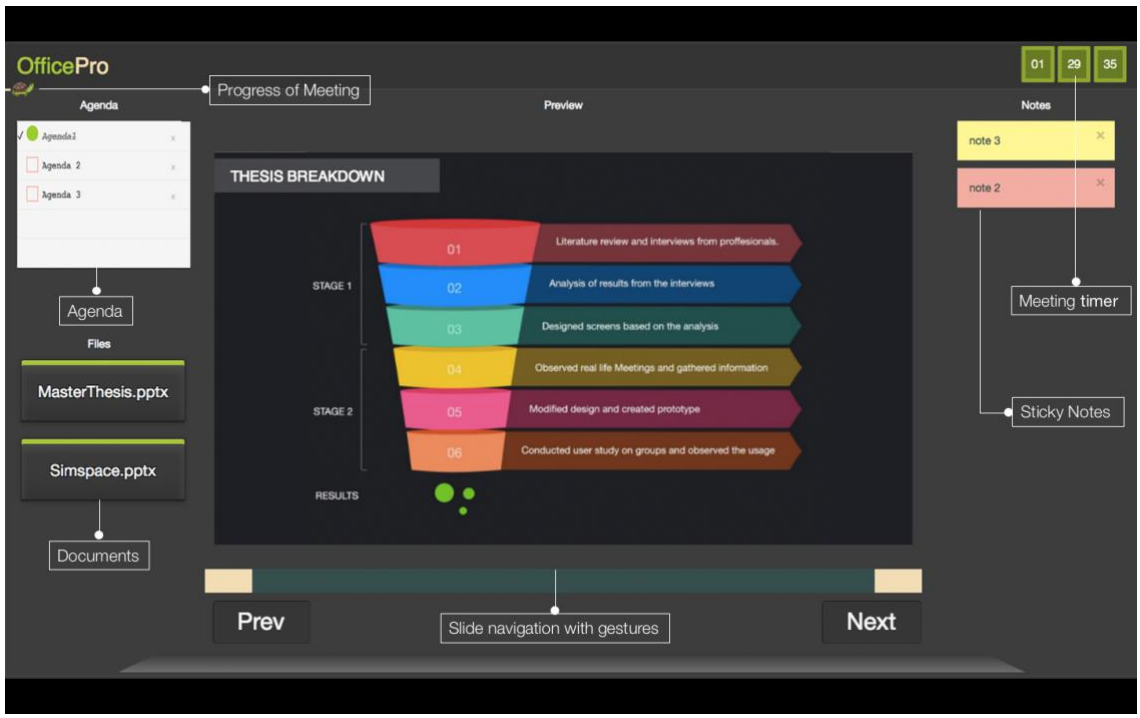

Figure 24. Modified meeting room display

The interface shown above will be displayed on a large screen where the meeting would be taking place. It consists of six sections in tandem with the previous meeting room design (Figure 24). Each section is described in detail below.

i) *Timer and Progress bar:* The countdown timer at the top right of the screen shows the time in hours: minutes: seconds. This is activated when the *Start Meeting* button is clicked. The progress bar is a visual indicator of how much time is left for the meeting to conclude. This design is a modification of the progress bar design done in Stage 1.

ii) Document preview and Navigation: The main section of the display is where the selected document will be displayed. The document can be selected either by hovering on the name of the document or by *dragging and dropping* it with the help of Kinect gestures. The design tries to mimic natural hand movements of picking and dropping an item. Apart from this, the slides and/or pages of the documents can be navigated either by placing the "hand" icon on *Next and Prev* or by a sliding gesture from right to left, to move to next page and vice versa.

iii) Agenda: The section on the top left is where the Agenda points will be displayed. Each point is entered before the meeting by one or more participants of the meeting. Any member can *"strike off"* a point indicating the end of its discussion, with the help of his mobile device as shown in Figure 24.

iv) Sticky Notes: The notes typed in by every user on his mobile device, will be visible here on the right side of the main screen. The users can edit a note or delete it. *The* notes can be colour coded as shown in Figure 24.

v) Document list and accessing: The list of files that are required for this meeting if they have been previously uploaded, will be displayed on the left, right below the Agenda. These documents can be a word file, a PowerPoint presentation or a pdf file. In the previous *meeting room design* at the end of Stage 2 (Figure 17 and Figure 22), the list of documents, were at the bottom of the display. Since we introduced gestural navigation in this stage to *drag and drop* the file to the preview area, it was seen to be more accessible to pick each file from the left side of the screen than from the bottom. When the user *grabs* a file from the list, the preview area will be highlighted and a message *"Drop file here"* will be shown to guide the user. A smooth interaction initiation is important for the user to feel comfortable enough to continue using the system. When the user successfully drops the file to the preview area, an audio feedback is given.

Before the start of the meeting, two things can happen. One of the participants can already update the Agenda from his mobile device or laptop and others can view or add more to the list. The participants of the meeting can also connect to the system and upload their files via their mobile phones or their laptops. This can be done before arriving at the meeting venue or while a meeting is in progress. Thus, all the documents from multiple group members will be already displayed on the large screen when they arrive.

When the meeting is about to start, one of the members clicks on the "*Start Meeting*" button on the far-right corner of the screen and this starts the countdown timer (Figure 24). The progress bar also starts moving at this point of time. One of the presenters can drag and drop their document to the preview screen and start the

presentation. They can move the slides via *left/right* swipe gestures or with the help of their mobile devices. Meanwhile the other participants can also control the slide on the main screen with their mobile devices. However, if a participant is viewing the screen via their laptop, the slide will move only according to his control and not according to the main screen. They can take down important points or type in their doubts or question using the *sticky notes* and these can be addressed at the end of the presentation. When one Agenda point is done, any member can "*strike it off*", indicating that the group can move on to the next Agenda point. The *"progress of the meeting"* indicator will show them how much time they have left to wrap up the meeting.

The designs for the mobile application is as follows:

Mobile device display

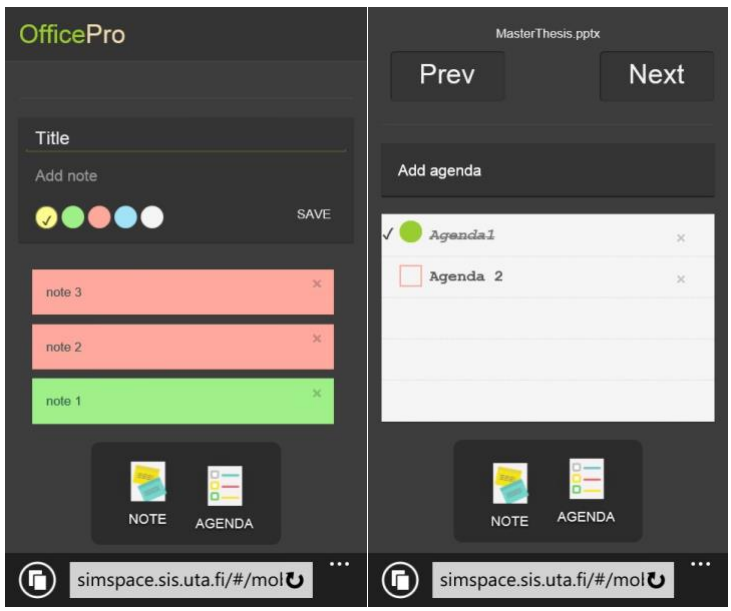

Figure 25. *'mobileApp'* UI controls to add notes and agenda

The interface shown above (Figure 25) will be accessible from a web browser on a mobile device. The components of this design are explained below.

i) Upload: The upload functionality helps users to upload their files that will be used for the upcoming meeting. This helps to have multiple files belonging to multiple users to be available in one place which can then be accessed seamlessly when the meeting starts or is in progress.

ii) Sticky notes: Colour coded sticky notes as described before, helps users to type in their opinion, doubts, remarks, points to remember etc., without interrupting the

presenter, while a presentation is in progress. They can be edited and/or deleted using the mobile device and the result will reflect on the main screen.

iii) Agenda: This functionality helps users to add in their agenda for the meeting in advance. They can be edited and/or deleted. Once an agenda point is done, any member of the group can *strike it off* from their mobile devices.

After the observational study described in Section 5.1, we saw how the screens designed in Stage 1 can be modified and applied to real life scenarios. The study shed light on some of the issues that users commonly face during meetings like the delay in setting up a laptop, or sharing the control of the presentation and so forth. Based on this analysis, the screens were redesigned to address these specific issues. Mobile and gestural interaction techniques were introduced to make information access and sharing more seamless. The design for the large screen display was modified to address the need for note taking capabilities and for users to view and navigating through their presentations without switching laptops or causing delays (Figure 24). The next section focuses on the modules and services that helped create a working prototype of the latest designs.

6. Implementation of OfficePro

This section focuses on the implementation of the designs mentioned in section 5.1. The prototype application developed was named as *OfficePro*. There are two components to the prototype: an interactive web based application which will be displayed on a large screen, and a mobile application (*mobileApp*) which can be used to perform various functionalities related to the main display. The following section explains how these two applications communicate and how the implementation was carried out (Figure 26).

As the user enters the space, the Microsoft *Kinect* detects the user. It tracks the user's position, movements and gestures. The user can interact with the system in two ways: one with his mobile device and the other via gestures. This gestural information is retrieved by the skeletal server application developed for the Information wall project [Mäkelä et al., 2014] . Once the user enters the space, he can view his documents and other information on the screen.

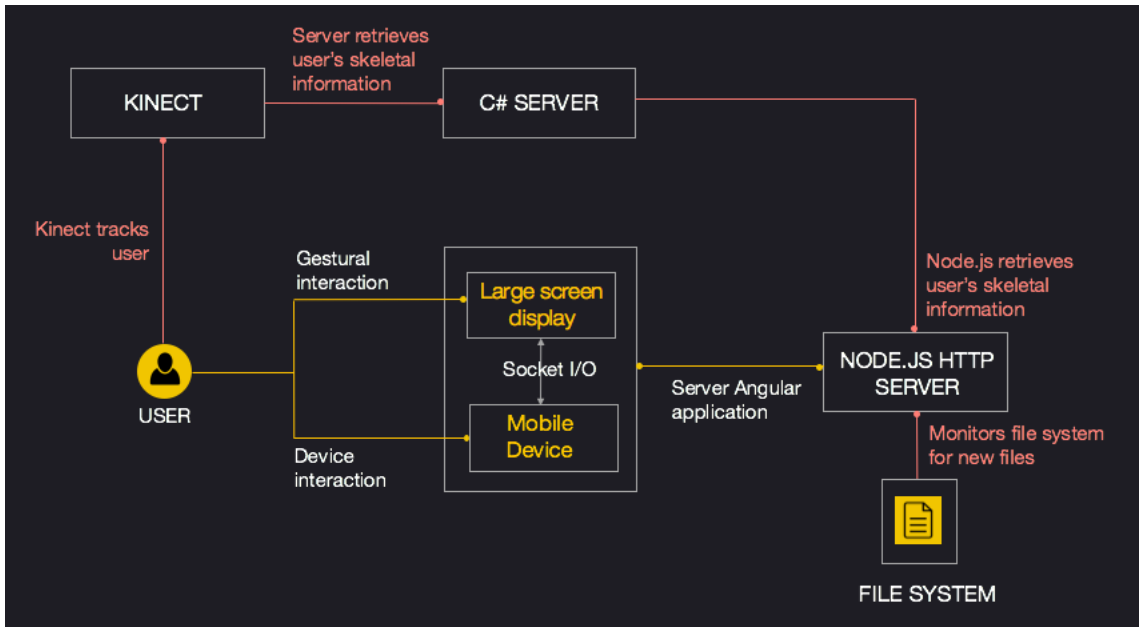

Figure 26. Implementation chart

6.1 Modules

The *OfficePro* ecosystem has an HTTP server that serves two client applications; a LSD (large screen display) client and a mobile client (*mobileApp*). The key modules and their functions are described below:

i) *User depth Module:* The skeletal server takes care of user detection, motion and gesture recognition. The Microsoft *Kinect* supplies this information to a locally run

C# server which will pass this user's gesture data to the large screen. The large screen polls for this information every 50ms.

ii) *HTTP server module:* A Hyper Text Transfer Protocol server hosts the web based application which is deployed on the large screen.

iii) *File watcher module:* The user's documents (Figure 20) are stored in a folder within the system. The node.js HTTP server monitors this file system for new files. When the node.js is up and running, it will keep looking in that folder for any file changes. If there are any, then the server will send a message to the large screen. The large screen client and mobile clients will maintain the latest files and depending on the client, the UI is rendered.

iv) *Communication module:* Utilises the help of Socket I/O to ensures that the actions done on the mobile, will reflect on the large screen. i.e. retrieving file information when a change occurs to it or moving the slides on the large screen with the input controls on mobile and so forth.

6.2 Interaction with the display

The interaction with the display can be done in two ways: one using the *mobileApp* and the other using gestures. One of the major challenges of designing public systems is to figure out a way to minimize additional hardware installation. For displays that will be used in multiple locations, it is important to use readily available hardware if possible and one of the most common devices that almost everyone has is their mobile device [Bazo and Echtler, 2014]. In our system, the *mobileApp* communicates with the main screen via the *Communication module*. The changes made on the mobile device are synchronised with the large screen. The mobile device can be used to move the slides on the screen. Another way to achieve this is via gestures. A hand shaped cursor moves according to the participant's hand and he can move to the next/previous slide by "grabbing and swiping" the page from right to left or left to right accordingly.

The next challenge was to identify where the user is at a given moment in time. Users also tend to move around quite a bit and common user behaviours like 'making space for a new user when he enters' and so forth needs to be taken into consideration when designing such systems [Boring and Baur, 2013]. This information was supplied by the skeletal server [Mäkelä et al., 2014] which acquired data from the Kinect. As the user enters the space and is detected, a small avatar pops up at the bottom of the screen and moves along with the user as long as he is in the field of view of the *Kinect* [James, 2015].

6.3 Methods

The next step was to **test the working prototype** with participants in a controlled setting. In this section, we discuss the methods used to conduct the user studies and the consequent details that occurred while conducting it. All tests took place in a controlled environment at the University of Tampere. The tests were video recorded and at the end of each meeting, a group interview was conducted. According to Crook [1994], the analysis of a collaborative interaction should be able to document specifically what each participant is able to contribute to the team. The idea of each study was to observe the usage of the system and to understand the usability and feasibility of the system. Contextual interviewing and systematic observation helped in discovering key usage points and also allowed the participants to recollect how they utilised the application. The questions for the group interview were prepared in accordance with this mode of experiment and the kind of responses that were being explored for, at the end of the study.

The procedure for the user studies were done following a script attached in Appendix 3.ii. The steps are explained here in brief.

i) The participants were welcomed into the meeting place.
ii) A demo of the system and the usage of its features was given by the moderator. The participants were asked to use their own mobile devices or laptops to access the *mobileApp*.
iii) The consent form in Appendix 1.ii was distributed to the participants.
iv) The video recording began after checking the consent forms.
v) The participants conducted their meeting as they would under normal conditions.
vi) The post experiment group interview was conducted based on the questions in Appendix 2.ii.

The meeting room consisted of a projector which displayed the browser window where the application was running. The display could be manipulated by a wireless keyboard which was also available to the participants to use. The participants were seated in a semi-circular fashion so that the display was visible to everyone. Before the meeting began, the moderator made sure that the *mobileApp* was up and running in each user's device.

6.3.1 Pilot Test

A pilot test was first conducted to obtain a preliminary analysis of the system and how users interact with it. This helped in realizing certain improvements that can be made in the mode of testing and also in the system which later proved to be very useful. The goal of the pilot test was to check the following:

1. Was the distance between the screen and seats provided to the participants a factor which influenced the usage of the application?
2. Was the initial demo given by the moderator, enough for the team members to understand the particulars of the system?
3. What were the initial responses to the system and its features?
4. What additional features could be added to improve the experience?
5. How much time will the teams be utilising the system for?
6. Does the ‘kind of meeting’ determine the usage of the system? For e.g. will the usage be different for a review meeting vs an introductory team meeting?

Based on the observations from the pilot study, certain changes were made to the subsequent user study plan, as well as to the application. The user study was then conducted on two teams with four and six participants each. The structure of the pilot study and the observations made are discussed below.

The Pilot test consisted of a group of 4 participants who were conducting their first project meeting for one of the courses at the University. The pilot test started off with a brief introduction of the system, its features and on how to interact with it. The documents they were to use for this meeting, had already been uploaded in the system and was visible on the screen. The meeting started when one of the participants proceeded towards the screen and started to navigate the pages of the document that was present on the screen, with gestures. When he was having some issues with it, one of the other team members reminded him of the briefing that was given at the beginning by the moderator on how to use the gesture navigation. The discussion began when they reached a particular page on the screen. The participant then came back and took his seat. One of the participants proceeded to use the keyboard to open a new tab. They do not use the application for the rest of the meeting. The keyboard was then predominantly used to go to other web pages and to view other documents in their OneDrive folder. The documents were zoomed, scrolled up and down, read and discussed. One of the participants was also taking down notes on a paper.

Since this was their first meeting, their aim was to understand the requirements of the project and to know more about what they needed to work on. Thus, they only had one document to upload and had to navigate to other websites to collect more information on their topic. This curtailed the further usage of the system. At the end of the test, a group interview was conducted and a set of questions were asked to the participants.

When asked about the frequency of use (or lack of) of the application, the consensus from the group was that they would've used it more if this was not their first meeting. They had to go through a number of documents from their private folders, navigate to a number of links and get an idea of what to do first, in order to carry on with the project meeting. One participant mentioned that if it were a bigger group, then the note feature would have been helpful especially if there is a participant who is silent or shy as compared to the others. Another suggestion was to have an option to drag the document displayed on the application to another place where they could edit it. A zooming option was also one of the suggestions for improvement. The distance from the screen to the seating area, or the gesture navigation were not a hindrance to the usage of the application. The participants said that the application and its features would be useful in their future meetings.

Lessons learnt from the Pilot and fixed:
The pilot test was instrumental in fixing some of the loopholes of the system. The following are the lessons learnt and changes made to better the study.

i) The group interview questions were revised to add in questions about their current project, the usage of gestures, the similarities and differences in this meeting as compared to their previous meetings etc. The revised questionnaire is provided in the Appendix 2.ii
ii) The test showed that the users while seated, preferred to use the keyboard to navigate to other webpages and also to navigate through the document. If their mobile devices could help them navigate through the slides, part of this problem can be solved. That is how the slider control for the *mobileApp* was devised.
iii) Initially the Agenda was viewable and not accessible to every participant. This was changed so that every participant could mark a point as "done".
iv) Certain bugs were corrected after the pilot such as fixing the repetitions in the Sticky notes which caused scrolling down on the mobile device impossible. This had hindered users from editing a previous note. Another bug that was fixed, enabled the Agenda to be made visible even if the screen was refreshed.
v) Countdown timer and progress bar were added after the Pilot test.
vi) The distance between the seats and the screen were lowered for better visibility.

6.3.2 User Testing

The user testing was performed on **two teams**. The first team consisted of 4 participants who were students at the University of Tampere and were working on a project to design a website as a part of their course curriculum. The second team consisted of 6 participants who were researchers at the University of Tampere and were conducting their monthly team meeting. The purpose of these user studies was to understand the following:

1. How the application affected their meeting?
2. Will the gestural interaction hold up against the mobile controlled navigation of slides?
3. To find any patterns in usage of the system and to understand the reasons for it.
4. How participants juggled between using their mobile devices while concentrating on the presentation and proceedings of the meeting?
5. How can their experience be improved?
6. If this will be a useful tool to be used in future meetings or on a larger scale and why?

The test was conducted in a controlled environment within the University of Tampere. The test subjects were previously informed about the nature of the study and asked to send in their documents for this particular meeting so that they could be available on the display when the team arrives at the meeting room.

6.4 Evaluation of the usage of OfficePro in the meeting scenario

The following section describes the observations made from the user studies conducted on the working prototype. The moderator took the role of a silent observer during the studies. The task of the moderator was to observe the actions of the users and to take down notes. The moderator also responded to queries from the participants regarding the usage of the application.

In the first study with the group of 4 participants, 2 of the users used the *mobileApp* on their phones. The participants were also referring to a notebook and one participant was taking down notes on a paper. One of the tasks of the group was to design a website. Therefore, they were referring to a number of pencil sketches and ideating around it. Each participant gave his ideas and those were added to the sketch. One of the ways the system was helpful was in reducing the number of papers that had to be handled manually and the mess that came with it. Having every document in one screen proved to be useful in this scenario. In the beginning, the keyboard was being used to open a new browser window to discuss about that particular website. The application was used more towards the end of the meeting. The only physical movement that took place was when one participant went closer to the screen to point at a particular section of the website they had opened. The transfer of control of the screens were done by passing the keyboard around. The application was used roughly for 20 minutes out of the 1-hour meeting. When asked about the reason, they said this was because, the topic they had to discuss was more design oriented and had to use paper sketches for ideation. Other reasons were: unfamiliarity with the system, missing features like edit, zoom and

also the time crunch to finish their task. The team said that with practice they could use the system in more meetings.

In second study consisting of a group of 6 participants, 2 of them were using the *mobileApp* on their phones and 4 had the application open on their laptop. A lot of impromptu sharing of documents occurred so that the participants had to plug in their laptops to share their screen. One participant tried to drag and drop a file to the *mobileApp* page which was open on her laptop. She misunderstood both screens to be the same and thus expected the document to open up like in the large screen display. She also was expecting the notes to be displayed in the same position of the viewport in both the mobile and the main screen. This was because in the *mobileApp* when you type in your notes, it comes one below the other but when you open this screen on a laptop, the notes are arranged horizontally from left to right. Hence the first note gets displayed on the left as opposed to the same note being displayed in the main screen on the right. This led to some confusion. But the users who opened the *mobileApp* on their phones had no such confusion as they could distinguish that both the screens where different. Although they realized that the application on their mobile phones had a different functionality as compared to the application displayed on the main screen, it would be useful to make slight changes to the visuals so that there would be a clearer indication of the differences in the applications. One of the participants closed her *Note* by mistake and expected a pop up to confirm the action.

Gestures were not used for navigation but the ‘slide controller’ (*Next* and *Prev*) on their *mobileApp* was used frequently by most of the participants (Figure 25). While giving a demo of navigating through the slides using gestures, one of the participant mentioned that the positioning of the Kinect makes it uncomfortable for the user to use the swipe gesture facing the screen and turn all the way back to face the audience and for every slide this would prove to be an issue. The ‘slide controller’ was the preferred means to navigate through the slides. The team commented that after the addition of a few above-mentioned features and the removal of bugs, they would use the system in the future.

An interesting observation found here was the varied usage of the *Agenda* section. Here the participant entered a ‘To-Do’ list or ‘tasks to be done’ in the *Agenda* section. The system could completely omit the use of print outs of documents if it had features to mark, zoom and edit content on screen and later sending the new documents to all the participants or updating their online copies. By doing this, the manual handling of paper will be required only during design and drawing tasks. When asked about their opinion on the usefulness of the *Note* section, two participants commented that it would be quite

useful in meeting with more than 5 participants and where there could be a shy participant tor two who would be more comfortable to post his opinions rather than speaking up. This feature is also useful when one participant is speaking, and another can take down his main points for reference later. A suggestion for improvement made by two participants was to add the possibility to connect the *Agenda* and *sub agenda* to *Notes* so that the users could write notes under each agenda point. They mentioned that they have never used an application before while holding a meeting and thus where not used to changing their pattern especially when they had a **time dependent** task.

In meetings, normally there would be a document at the end that contains the minutes of the meeting and a rough description of what tasks are to be done before the next meeting and whom they are assigned to. This document will normally then be emailed to all the participants later. One participants preferred to have one large editor to type in notes and to edit them. That was a feature which could be added in the next iteration where all the notes could be combined as one document and emailed to all the participants. The ticking of *Agenda* was a feature liked by majority of the participants. It was intuitive and helped share responsibilities. When one *Agenda* point was discussed and done with, one of the participants would mark it as 'done'. The responsibility was not on just one person. One of the participants mentioned what was different from his previous meeting was that it facilitated turn taking. For example, usually during a meeting when a participant is speaking on a topic and when he is done, there is a pause before another person speaks. This is usually done to make sure that the first person was done speaking. But while using the system, when a person was done with the topic, he would mark it as 'done' by striking it off on his mobile and this was a clear indicator to the others that they could proceed with the next point. The *Agenda* list could be sometimes more elaborate than expected. So, in the future, the space allocated for the agenda should be adjustable according to the needs of the specific meeting.

Constraints

Seating arrangement and drawbacks of Kinect

The Kinect 1.8 was used for this application for the gestural interaction. When a user is detected, an avatar appears and a when the user moves his hand, a corresponding hand icon moves along with his gesture. When the participants were seated, the Kinect detected their hand movements even when they were not trying to use gestures. Thus the hand icon kept moving hitherto on the screen. Initially when the application was in its conception stage, the idea was to have people seated around a screen and for every user to be able to navigate the slide in the seated position. But the positioning of the Kinect and its current 2-person detection system rendered this idea impractical to implement.

The system requires a certain level of 'getting used to' in order to efficiently use it.

The participants from the user studies commented that since they have never used an application such as this before in any meeting, there was some initial hiccup in using the system. One critical aspect that was kept in mind while designing the system was to seamlessly integrate it to the current working scenario of a regular meeting. However, any new system when introduced, requires the users to follow a learning curve before they can understand and efficiently utilize all the features of the system.

6.5 Results of Stage 2

This section describes the results of Stage 2 which focusses on the "Meeting room scenario". These results portray the comparison between the *review meeting* observations (Figure 17 and 22), it's issues that we discussed in the previous sections and how the system helped eliminate or improve certain situations that occur during meetings. This section also brings out the drawbacks of the current system and how it affected the participants during the user study and the lessons learned from it. From this study, it can be suggested that the users of a collaborative set up mainly look for three aspects: *visibility, flexibility and involvement*. They are further explained below with examples from the study.

Visibility

Users likes to have a clear understanding of what is going on and one of the key functionalities of any interactive system is its ability to keep the user informed on various aspects of the system and to provide clarity in terms of usage. In Jacob Nielson's 10 Heuristics [Nielsen, 2006], he explains how visibility of the system status is an important heuristic to be followed when designing applications. Adding to that, from the study we can also say that, for large interactive displays where there could be a significant amount of data to be shown, it is of importance to have clear distinction between the various data fields and to have clarity on how users can access the required items. The term WYSIWYG (what you see is what you get) is a term used to describe text editors and following that analogy in an experimental study called *The Colab* [Sibley et al., 1987] described in Section 3.3, this term was redefined as WYSIWIS (what you see is what I see). This refers to presenting consistent, shared information to all participants.

i) *Showing the progress of the meeting was useful:* It is a common occurrence in meetings for the members to overshoot their meeting duration and thus having to consciously check their phones or watches to be wary of the time. The countdown timer in Figure 24 lets them know the time left for the meeting and the progress bar (Figure 24) gives a fun animated touch to portray this information without causing a distraction to the users.

ii) *Having all the documents in one place reduced confusion and made them readily accessible:* All the participants agreed that having several relevant documents in one place was highly useful and reduced a lot of hassle with respect to plugging and unplugging laptops, browsing through online drives or having to open up their emails to find the required document. This also saved time and effort and facilitated a smoother transition between presenters. The availability of multiple options to

display a document meant that a presenter who is standing up on the dice or a participant who is seated can effortlessly access a document from the list and can toggle between them in case of a scenario where one agenda point needs reference to several documents.

iii) *The space allotted for Agenda is not sufficient:* In real life meeting scenarios, sometimes the agenda list can be exhaustive and include a number or points and sub-points. The layout currently provided for Agenda in the screen design might prove to be insufficient. There has to be an alternate design in order to accommodate this requirement as two participants had commented that seeing the agenda at all times was very useful.

iv) *The similarity in design of the Mobile App screen and main screen caused confusion:* The *mobileApp* and the main display screen was designed around the same theme and colour scheme to intentionally invoke association. This however was discovered to lead to some confusion as the designs looked almost similar in one particular context. The reason for this could be that the explanation given by the moderator right before the study was not thorough enough for the participant to grasp the idea completely, or it could be because in that particular scenario, the participant had expected the system to work a certain way. Since this happened only once during the studies, the take away from this experience is to make minor changes in the design so that the participants can clearly distinguish between the varied functionalities of the main display and that of mobile device.

Flexibility

An interactive system, especially one which caters to multiple users simultaneously, should have a certain level of flexibility in terms of usage and its ability to adapt to various situations. The system should provide the user, an opportunity to choose what he wants to see and how he wants to see it. This should also leave some space for the system to use its intelligence to make available, only a certain set options based on the context, so as to not overwhelm the user. In her journal article, Oviatt [1999] denotes the flexibility that users have in alternating between input modes as a significant advantage of multimodal systems. Having multiple entry modes via the mobile device and the gestural interface was tested to see if there was a preference. Another concern in terms of multi user set ups are how to equalize access to all users. The note taking feature allowed all participants to write independently at the same time. Understanding user behaviour and analysing patterns would help design optimized systems that enhance predictability and to further avoid error prone situations. The following points

are based on how the flexibility aspect of our system was received by the users and what their feedback was on features that did not cater to their needs.

i) *Navigation of slides became much easier:* One of the issues that stood out during the initial observation of review meetings was the difficulties in navigating through slides when the presenter is not near the laptop that is connected to the projector. The usage of a mobile device to control the slides of a presentation made it easier for the participants to navigate through their documents without depending on another person. The gestural interaction was also introduced to eliminate this issue but the **participants preferred to use their mobile devices** to carry out this task.

ii) *Each member having control of the slides made discussing a previous topic easier:* The practice of asking a question about a previous topic is a common scenario that occurs in meetings not just confined to review meetings. This mostly occurs when the presenter is for e.g. on slide 4, and one of the participants or reviewer asks a question or seeks clarification about a topic discussed in slide 2. When this happens, the person asking the question can himself navigate to the said slide and continue his comment or question, now with better perspective, which helps everyone to be on the same page.

iii) *Inability to Zoom in and out caused issues:* When dealing with documents on a large screen, the ability to read it comprehensibly is of utmost important. Although the application can work perfectly with Power Point slides, when it comes to Microsoft Word documents or PDF files, the size of the text does not seem to be large enough to make it readable from a distance and thus the participants proceeded to try and zoom-in the text. Currently this feature has not been incorporated in the system and therefore made the reading of some part of the documents problematic.

iv) *Inability to draw or to open a video hindered the flow of the usage of the system:* One of the teams had a link attached to their document and this was a link to a video file. The application needs to integrate a feature which lets users watch videos in the same preview panel as the documents. This would prevent the participants from having to navigate to another page to watch the video.

v) *Customizable components:* The system currently gives provision for writing Agenda points and marking them as done, with a tick. Two participants mentioned that they would require a provision for adding one or more sub-agenda points to an existing *Agenda*. When using the *Note* feature, the same participants wanted to

have a function to link a particular *Note* to an *Agenda* or sub agenda point as this would be useful for the team members to understand and relate the notes when they revisit it later.

Involvement

Displays in collaborative settings are meant to facilitate interaction between all participants. One of the ways the system can cater to this is by giving all its users an equal opportunity to participate. To take it one step further, the system can be designed in such way as to not make this participation seem mandatory. There could be various reasons why a participant may not want to engage in discussion. Such systems should cater to this basic human behaviour and provide alternatives to having just one fixed form of communication/interaction.

i) *Intuitive design of Agenda helped in sharing of responsibilities:* Two of the participants commented that the design of Agenda was intuitive and that it stimulated a real-life action when we *"tick off"* something when it's done. It also helped in sharing the responsibility, whereas traditionally it is either the moderator or the leader of the group that *"ticks off"* an Agenda notifying its completion. Sometimes it so happens that there is a pause after a speaker is done, where the rest of the members wait for a vague signal from the speaker to let the group know that he is done. One participant commented that the physical action of completing a point when the speaker was done, was useful to indicate that the group could now move on to the next topic.

ii) *Sticky notes are useful for the "shy" person in a large group of people:* The idea of sticky notes (Figure 25) was formulated to tackle two issues. One was to reduce the responsibility on one person to keep up and note down the key points of the meetings. And two, to encourage everyone to take part in the discussion. This functionality facilitates involvement from all members of the group to participate and add in their opinions, doubts or questions about a particular topic so that it can be discussed and/or be documented. Two of the participants commented that this in-turn would also help the "shy" person in a group to voice their opinion who otherwise may find it a little difficult to stand up and speak sometimes.

Other observations and areas of improvement:

i) *Dependency on mobile phones may lead to distractions:* One major concern while deciding to add the mobile component to the system was the associated dependency and the distractions that may occur with its usage. This was proven to be true when one participant mentioned that he did check his social media message notifications

while participating in the meeting as the application's dependence on the device made it easier to keep checking the screen for personal reasons. Although this may result in a few moments of distraction, it did not seem to largely affect the participant's involvement in the meeting nor did it cause any inconvenience to the other members.

ii) *Hitherto navigation of slides is a concern:* There could be occurrences where, a presenter while navigating through the slides or while speaking on a topic, can get distracted by another user's actions relating to the screen. For e.g., a user might click on the *Prev or Next* (Figure 25) buttons on his mobile device there-by changing the slide and the presenter might be caught unaware. This may prove to be a distraction to the speaker and he may lose his train of thought when the slide switches abruptly.

iii) *Gesture was not used as much as the mobile navigation:* Data exploration requires tools that are precise and easy to use. Gestural interaction has not reached a stage of accuracy where users can perform tasks within their expectations of latency. Apart from the technical constraints related to Kinect and its accuracy issues, there were other *performance awareness* issues that were more dependent on the behavioural aspect of the participants. A study by Hinrichs et al. [2008] on large interactive displays in museums, found out that their participant's engagement with the system was affected by this behavioural aspect. The participants using the display were aware of being observed by others in the vicinity. Hence, one of the assumptions made during the beginning of this thesis study was that the participants would use less of the gestural interaction. And as anticipated, the participants clearly preferred alternate means such as using the keyboard, or mobile phones to navigate through the slides instead of using the gestures. The reasons for this could be the inexperience in using hand gestures, lack of time needed to figure out how the interactions work and also the behavioural inhibitions associated with it as stated above.

Another reason why gestures were less preferred, could be the ready availability of an alternate method to carry out the same task. Any system that incorporates multiple modalities should be context aware and adapt to the user behaviour. The possible solution to improving the user experience would be to have a multi modal system that seamlessly switches control between the various interaction techniques available to the user based on context.

7. Conclusion

The first stage of the study aimed to seek information related to software development environments pertaining to the individuals involved and the also the collaborative process as a whole. The second stage focused on one particular aspect of collaborative workspaces to implement an application that aids a meeting scenario and to observe the usage. The research is expected to give valuable data for researchers on how the combination of gestures, cross device interaction, and a large screen display can help bridge the gap between data on paper and actual visualizations and how it can facilitate collaborative dialogue in software companies as well as academic institutions. The study hopes to be a small step in the process of providing guidelines and design solutions to depict relevant software related information on large screen displays. The study also provides further suggestions for improvements in the following section which details the ideas for the next iteration of the system.

The observations and interview results from Stage 2 were helpful in bringing forth new ideas for improvements in the next iteration of the system design. The application with respect to the *Meeting room screen* design (Figure 24) can undergo a number of additions to make it more user-friendly and efficient for the participants of a meeting. On a broader scale, the system can also incorporate new fields and designs more in tandem with the designs of Stage 1 so that it can also be utilised for industrial and academic use. These would include setting up databases for retrieving the company's information and meta data in order to fuel the analytics of various functions such as progress of a project or depicting employee information. In terms of industrial usage, having visibility of a page in Confluence or linking to a Jira item would be a feature that would reduce rework, if the changes made could be updated in all applications simultaneously.

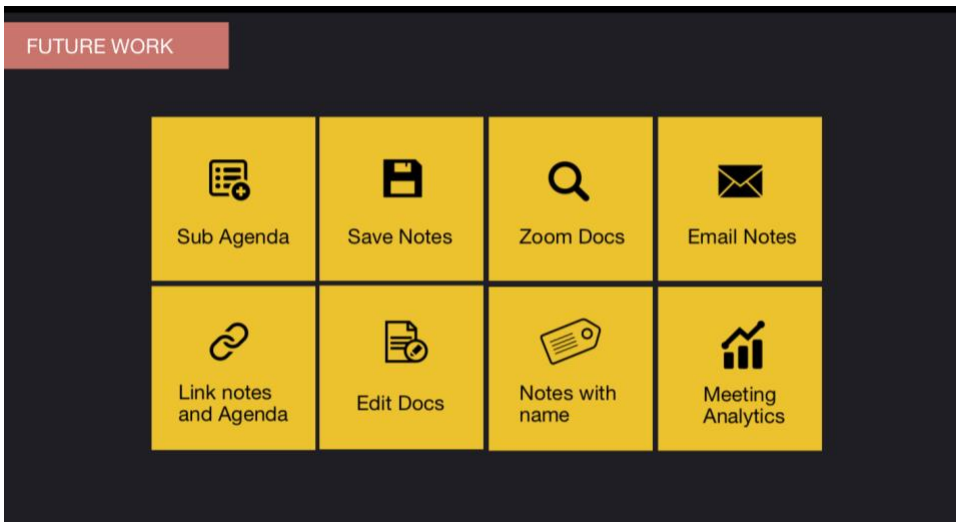

Figure 27. Future work

Lack of provision for sub-agendas and inability of the application to link one or more sticky-note item to an Agenda point, are one of the things to improve upon. Having a document which compiles all the notes into one would be an essential addition. This document can then be automatically emailed to all the participants or other additional people as required, at the end of the meeting. Whether the names of the person who typed the note is a necessary requirement or not has to be further questioned, because in the current design, the anonymity of the notes was not a concern for the participants. Providing feedback to the user when an unexpected event occurs, is of high priority and will ensure the smooth running of a meeting.

As far as documents are concerned, it would be useful to have an on-screen editor which does the same functions as a Microsoft Word program. But rather than creating a new application for it, it would be more pragmatic to have the document open in a dedicated editor (by dragging and dropping the document or by speech input) so that its functions such as edit, zoom etc., can be utilised.

The future iterations can also be made more person specific by having options to assign tasks to each member and to have an automated email with that information sent to each person. Another option is to have a designated space in the cloud pertaining to each participant or group, which can automatically update the typed notes/tasks/assignments on it. Usage of RFID tags can be useful for the system to identify the team members and also to detect who typed which note. This information can them be depicted in Meeting Analytics where members can know how much time each person took to present and which slide or page was discussed the most. These analytics could also derive data from companies to show graphs and charts with information about the progress and activities of the team as discussed in Stage1.

With the insight obtained from Stages 1 and 2, the system can be developed to incorporate the best of both stages along with rectifying the drawbacks and shortcomings of each. Studies are being carried out to measure engagement using gestural recognition, and this can also be one of the areas for the system to explore in the future. The benefits of AUIs or *Attentive User Interface* [Vertegaal et al., 1997] and attention centric systems [Horvitz, 1999] can be leveraged in order to understand the priorities of the user and to adapt the system to display the most relevant content. Such a system can thus be utilised effectively for academic and industrial use. The challenge is to ideate a system that can be both scalable to the ever-growing requirements of the domain and at the same time adhere to the key functions identified in this research i.e. of *visibility, flexibility and involvement*.

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Appendices

Appendix 1(i)

CONSENT FORM STAGE 1

PRESENTING INFORMATION ON LARGE SCREEN DISPLAYS IN A SOFTWARE DEVELOPMENT ENVIRONMENT

GENERAL: You are invited to participate in an interview for a study that will seek to learn what kind of information would provide clarity to a software project's progress for different internal stakeholders and how a large in-office display could facilitate collaboration amongst them. In this interview, subjective responses from participants will be used as a data gathering method.

DESCRIPTION: The interviewer will ask you certain questions pertaining to your work in this field and your company specifically. The interview questions will be focused on your experiences and opinions about working with a global team. This interview seeks to learn about the day-to-day activities of a software team and the individual and group communication that takes place in order to get things done.

DURATION: The interview will be around 20-30 minutes.

BENEFITS: The study will result in devising new interfaces for communication, feasible interactive techniques and design models/guidelines aimed at improving usability and enhancing the experience of working in a global software company.

PARTICIPANT RIGHTS: All the data collected during this experiment will be handled anonymously, and will not be connected to the person or the company. The participation is voluntary, and you can cancel your approval to participate or stop the interview at any time without any consequences.

By signing this consent form I agree to participate in the experiment, and I understand the conditions. I have fully understood that participation is voluntary, and I am entitled to refuse to participate or stop the test at any time without any consequences.

SIGNATURE:

_____

DATE AND PLACE:

_____

CONTACT INFORMATION: If you have any questions, concerns or complaints about this experiment, please contact Draupathy Balaraman (+358 44 956 3200, email draupathyb@gmail.com).

1(ii)

CONSENT FORM STAGE 2

IMPROVING TEAM COLLABORATION WITH THE HELP OF A LARGE SCREEN DISPLAY

GENERAL: You are invited to participate in a study that will seek to learn how a team behaves in the course of a meeting and how they utilize the resources of the application.

DESCRIPTION: The moderator will show you a demo of the system explaining the features. Then you will be asked you to carry on with your meeting. At the end of the meeting the moderator will ask you as a group, a few questions about your experience with the system. For research purposes, the meeting and the interview will be recorded using a video recorder.

DURATION: The study will be for the duration of your meeting.

BENEFITS: The study will result in devising new features and interfaces for collaboration, feasible interactive techniques and design models/guidelines aimed at improving usability and enhancing the experience of taking part in a collaborative meeting.

PARTICIPANT RIGHTS: All the data collected during this interview will be handled anonymously, and will not be connected to the person or the team. The participation is voluntary, and you can cancel your approval to participate or stop the study at any time without any consequences.

By signing this consent form I agree to participate in the study, and I understand the conditions. I have fully understood that participation is voluntary, and I am entitled to refuse to participate or stop the test at any time without any consequences.

SIGNATURE:

_____

DATE AND PLACE:

_____

CONTACT INFORMATION: If you have any questions, concerns or complaints about this experiment, please contact Draupathy Balaraman (+358 44 956 3200, email draupathyb@gmail.com).

Appendix 2 (i)

INTERVIEW QUESTIONS STAGE 1

(for Finnish participants)

1. What is your job role?
2. How long have you been working for the organization?
3. What are the main activities that make up your job?
4. Who do you communicate most frequently with on work matters?
5. What information do you rely on during a normal working day?
6. Where do you obtain this information from?
7. What ideas can you think that would support collaborative work amongst peers?
8. How often do you have to communicate with a co-worker abroad?
9. Were there any typical problems that you noticed?
10. What information about your co-workers and about their life in that country would you be interested in knowing on a day-to-day basis?
11. Do you have any memorable conversations with your colleagues' abroad that you can think of?
12. What information about yourself would you like to share with your colleagues that would aid in a better work relation with them?
13. If there were a large screen display in your office, what would like to see on it?

(for Non-Finnish participants)

1. What is your job role?
2. How long have you been working for the organization?
3. What are the main activities that make up your job?
4. Who do you communicate most frequently with on work matters?
5. What information do you rely on during a normal working day?
6. Where do you obtain this information from?
7. What ideas can you think of that would support collaborative work amongst peers?
8. How often do you have to communicate with a co-worker abroad?
9. Have you worked for a software company abroad?

10. If yes, with regards to the work culture were there any typical differences that you noticed?
11. What information about your co-workers and about their life in that country would you be interested in knowing on a day-to-day basis?
12. Do you have any memorable conversations with your colleagues' abroad that you can think of?
13. What information about yourself would you like to share with your colleagues that would aid in a better work relation with them?
14. If there were a large screen display in your office, what would like to see on it?

2(ii)

INTERVIEW QUESTIONS STAGE 2

(Pilot study)

1. What is your opinion about the system?
2. Is there a particular feature that you liked?
3. Do you think the system helped your team collaborate better? If not what caused the hindrance?
4. Would you use this for your next meeting?
5. What in your opinion, could be a disadvantage of this system?
6. What additional features can you think of for this system to make it more robust during a team meeting?

(User study)

1. Can you tell me what this project is about and what is the purpose of the meeting?
2. How did the application affect your meeting?
3. What were the similarities and differences as compared to your previous meetings?
4. Is there a particular feature that you liked?
5. Do you think the system helped your team collaborate better? If not what caused the hindrance?
6. (if gestures were used to navigate the slides) What do you think of the feedback mechanisms in the gesture interaction?
7. (if gestures were not used) Why did you choose to navigate using the keyboard or buttons instead of the gestures?
8. What in your opinion, could be a disadvantage of this system?
9. What additional features can you think of for this system to make it more robust during a team meeting?
10. Would you use this for your next meeting?
11. Do you have any other comments or suggestions?

Appendix 3(i)

SCRIPT STAGE 1

Welcome the participant to the room.

"Hello, my name is Draupathy. Thank you for your participation. This interview is a part of my thesis and I am interested in gathering information from people who have experience in working in a software company.

I will briefly explain what my thesis topic is about. My focus is on displaying information on a large screen display that is placed in a software company. This display would have all kinds of information that is relevant to the company and its employees. It could be regarding your project and its progress or about the daily activities that are involved in the project. I am also interested in using this tool to improve collaborative work amongst team- mates.

Do you have any questions at this moment?"

Answer if any.

Hand over the Consent Form 1

"Would you go through this consent form and sign below if you agree to the terms?"

Check the consent form and keep aside.

Place the audio recorder near the participant and remind them that this interview will be recorded starting now.

Switch on the recorder.

"Next, I am going to present some sketches for displays. These are just ideas to provoke ideas, not actual prototypes. I will show these one by one, and you are welcome to freely express your thoughts and ideas based on the sketches and any further thoughts and ideas that come into your mind. Do you have any questions at this point?"

Participants and screen order *(Screens 1 and 2 remain together)*

9 – 10: Participant 1
1 2 3 4 5

10 – 11: Participant 2
4 1 2 5 3

11 – 12: Participant 3
3 3 1 2 4

13 – 14: Participant 4
4 1 2 5 3

14 – 15: Participant 5
3 4 5 1 2

15 – 16: Participant 6
3 4 2 1 5

Place the image in front of them and explain it. Ask them what they think about it and if they have any ideas to add on, or another suggestion.

"What are your thoughts about the screens and about this idea in general?"

Thank the participant for their time and switch off the audio recorder.

3(ii)

SCRIPT STAGE 2

Welcome the participants to the room.

"Hello, my name is Draupathy. Thank you for your participation. This study is a part of my thesis and I am interested in observing how a team of people utilize this application for their meeting.
"The application is not currently fully developed so if you face any issues, don't worry about them. It's not you, it's the system!"

I will briefly explain what its features are with this demo:

Can you go to this website:
www.simspace.sis.uta.fi/

1. Upload files
2. Drag drop file or click file
3. Navigate through the document

Can you go to this website on your phone:
www.simspace.sis.uta.fi/#/mobileApp
You can use your phone to type in your thoughts, or important points that you may want to remember etc. with the help of these sticky notes.

4. Agenda
5. Sticky notes

One of you can click on start meeting when you want to start the meeting and a countdown timer will appear along with a progress bar.

My task will be of an observer. I will also be video-taping the test.

Do you have any questions at this moment?"
Answer if any.
Hand over the Consent Form 2
"Would you go through this consent form and sign below if you agree to the terms?"

Check the consent form and keep aside.
Start the video recorder and remind them that this study will be recorded starting now.

Once the meeting is done, ask the participants if they mind answering a few questions regarding their experience with the system. Refer to the Group Interview questions.
Once the interview is done, thank the participants for their time and valuable comments.

Stop recording